Recreational preferences in relation to stand treatment practice in young pedunculate oak

An empirically-based international comparison

Claudio Petucco

Supervisors: Jens Peter Skovsgaard, *Southern Swedish Forest Research Centre, SLU*
Frank Søndergaard Jensen, *Forest & Landscape Denmark, KU*

Swedish University of Agricultural Sciences

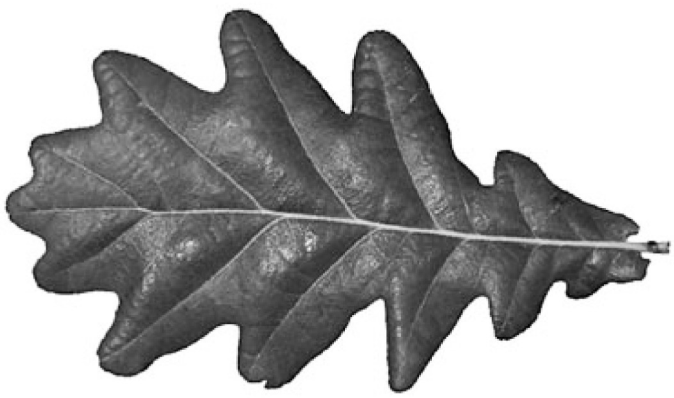
Master Thesis no. 176

Southern Swedish Forest Research Centre

Alnarp 2011

Recreational preferences in relation to stand treatment practice in young pedunculate oak

An empirically-based international comparison



Claudio Petucco

Supervisors: Jens Peter Skovsgaard, *Southern Swedish Forest Research Centre, SLU*
Frank Søndergaard Jensen, *Forest & Landscape Denmark, KU*

Examiner: Per-Magnus Ekö

Swedish University of Agricultural Sciences
Master Thesis no. 176
Southern Swedish Forest Research Centre
Alnarp 2011

MSc thesis in forest management, 30 ects,
advanced level, SLU course code EX0630

To Francesco, my friend

Recreational preferences in relation to stand treatment practice in young pedunculate oak: An empirically-based international comparison

Abstract

The aim of this study was to investigate recreational preferences for contrasting stem densities in young stands of penduculate oak. In particular, variations in preferences were examined in relation to the respondents' affiliation with forestry and their nationality. Due to the increasing importance of oak, especially in the context of urban forests, knowledge of such preferences could have strong implications for future management practices of oak. The study was based on five pairs of colour photographs from each of five recently thinned plots in a 13-year old experiment. The plots presented five different residual stand densities: 7000 stems ha^{-1} (unthinned), 5300 stems ha^{-1} (traditional thinning), 1000 stems ha^{-1}, 300 stems ha^{-1} and 100 stems ha^{-1}. All cut trees were left on the ground. The study was carried out as an European survey of forestry as well as natural resources professionals and students based on questionnaires. Interviewees ranked the photographs according to the criterion: "Which forest environment do you prefer as a visitor?". Results showed that there are geographical variations in the assessment of young stand practices. Southern European respondents favoured stands with 7000–5300 stems ha^{-1}; Danes, British and Irish singled out stands with 1000 stems ha^{-1}, whereas Scandinavians tended to rank higher more open stands. Data on the Danish general public from a previous study were analyzed and results compared to the Danish professionals. The principal component factor analysis showed that the general public tended to perceptually group pictures according to similar overall patterns of openings, presence of row structure and stand accessibility. The latter resulted to be more important than stand density: as long as the stand appears accessible, stand density can vary substantially (5300–300 stems ha^{-1}). On the contrary, foresters seemed to perceptually group pictures according to treatment type, and the presence of slash had very low influence in shaping forestry professionals' preferences. This suggested an influence of a forestry background on recreational preferences, making foresters more willing to tolerate the visually negative effects of silvicultural intervention.

Keywords: Forest aesthetics, forest recreation, scenic beauty, *Quercus*, oak, slash, stand density, precommercial thinning, young stands, principal component factor analysis, Europe.

Author's address: Claudio Petucco, SLU, Southern Sweden Forest Research Centre, P.O. Box 49, SE-230 53 Alnarp, Sweden.
E-mail: clpe0001@stud.slu.se

Cover photo: Downloaded on April 12, 2011 from `classes.hortla.wsu.edu`

Contents

1 Introduction

In many parts of Europe oak is increasingly used for afforestation and when regenerating long-established forests. In Denmark, as well as in other part of the North-western Europe, this afforestation process has been carried out in urban or periurban areas where the demand for forest recreation is high. However, the numerous young stands are mostly managed to promote the long-term economic potential and little considerations are given to other management objectives during precommercial thinning operations.

Some years ago, statistically designed field experiments were installed in young stands of oak to investigate effects of alternative precommercial thinning practices on a range of tree and stand characteristics. Shortly after the first precommercial thinning, each plot was photographed and the pictures were used in a survey investigating the influences of precommercial thinning practices on recreational preferences of the Danish adult population in these type of stands (Jensen and Skovsgaard, 2009).

In this master thesis, a similar survey with the same photographs was made among forestry professionals and forestry students from different parts of Europe. The aim was to analyze the response from foresters and students and compare the results, firstly, with the recreational preferences of the Danish general public and, secondly, across Europe. Due to the increasing importance of oak, especially in the context of urban forests, knowledge of such preferences could have strong implications for future management practices in oak forests.

In the rest of this introduction, the framework in which this study takes place is analyzed in details. The description of the afforestation process and its political foundations are described in Section 1.1. The new questions and challenges brought up by the increase of the woodland especially close to the urban areas are discussed in Section 1.2. In Section 1.3, the traditional silvicultural management in young oak stand is presented, whereas in Section 1.4 the tools to incorporate visitor preferences into silviculture is introduced by a short literature review of the analysis of recreational preferences on forest recreation. In the last two Sections, the previous studies investigating the silvicultural implications of recreational preferences in young stand and the aim of this study are respectively described.

The rest of this thesis work is organized as follow: Chapter 2 presents the data and the methodologies. In the Chapter 3 the results of the analysis are illustrated. The discussion of the results is included in Chapter 4. Finally, Chapter 5 briefly concludes.

1.1 Afforestation in Europe

Over the past twenty years, in Europe the area covered by forests and other wooded land slowly increased by approximately 0.3% annually (EUROSTAT, 2009). To a major extent, this increment has been a consequence of specific policies at both the European and national level: the former through forestry measures included into the common agricultural policy (CAP); the latter through country specific measures (Weber, 2000).

In particular, the EEC Regulation number 2080/92 (The Council of the European Communities (EEC), 1992) was intended to promote the afforestation of agricultural land by means of financial incentives to landowners. The purposes of the aid scheme were, among others, to increase the amount forest resources, to contribute towards forms of countryside management more compatible with environmental balance and to combat the greenhouse effect (du Breil de Pontbriand, 2000). In 1999, a new agreement was reached concerning the agricultural aspects of Agenda 2000, shaping the new CAP. According to du Breil de Pontbriand (2000) in the new framework, the Member States played a more crucial role, deciding whether to support schemes for the afforestation of agricultural land or not, while the implementation of the scheme was previously mandatory.

Turning to the national level, plans for afforestation were characterizing the political priority in many European countries, in particular in the forest-poor North-westesten region: Ireland, United Kingdom, Denmark, Iceland, Belgium, The Netherlands, and North-eastern France. According to Nielsen and Jensen (2007), all these countries have plans for considerable afforestation, with a target set to approximately 3.5 million ha of new forest (Table 1). A significant amount of forest expansion occurred also in Southern Europe (Greece, Italy, Portugal, Spain) due to farm abandonment and rural emigration processes as well as the decoupling of support from agricultural production (Zanchi *et al.*, 2007).

In Figure 1, it is possible to observe that the increment of the forest area due to afforestation of agricultural land, during the first five years of application of the EEC Regulation 2080/93, was approximately of 1 or 2% for most of the European countries, with the only exception of Ireland where the forest area - one of the smallest in Europe - soared by 16%. According to Sondag (1999), this afforestation was carried out mostly on permanent grassland, with the exception of The Netherlands and Denmark, where it was implemented almost exclusively on arable land.

The species planted were in most cases broadleaved, as depicted in Figure 2.

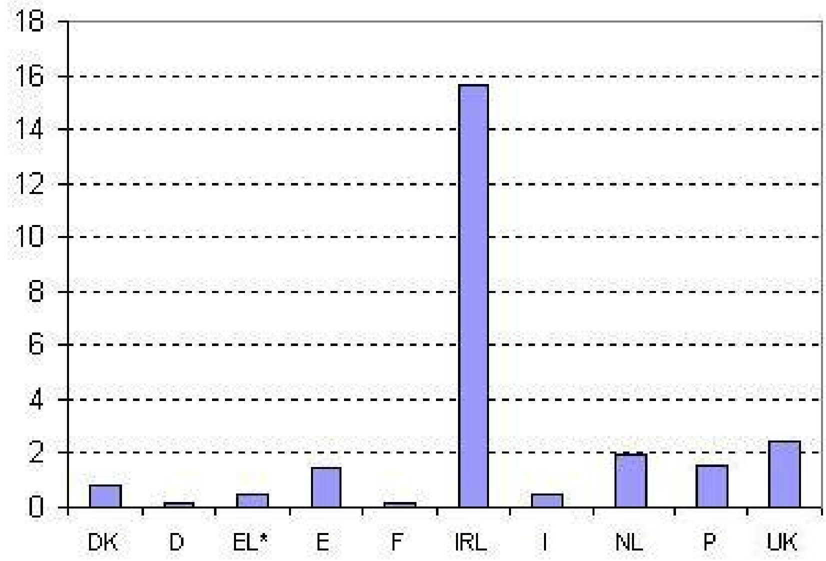


Figure 1: Area of agricultural land afforested under Regulation 2080/92 between 1992 and 1997 as a proportion of the total wooded area in 1997 (%) [Source: Sondag (1999)]

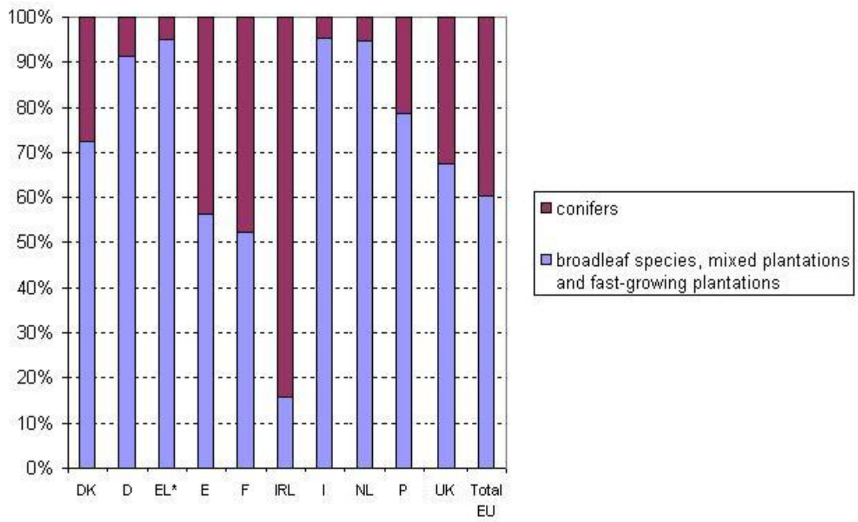


Figure 2: Breakdown of the area of agricultural land afforested between conifers and broadleaf species [Source: Sondag (1999)]

Table 1: Forest cover and planned afforestation in countries within the North-western European forest region

Country	Forest cover	Strategic goal for forest cover	Planned afforestation
Ireland	9.6% (659,000 ha)	17% in 2030	700,000 ha
United Kingdom	11.6% including Wales and Scotland (2,790,000 ha)	Double the forest cover (c.a. 20%)	c.a. 2,000,000 ha - 12,000 ha/year
Denmark	14% (485,000 ha)	Double the forests cover in 100 years (20%)	c.a. 400,000 ha. Goal is 5000 ha/year
Iceland	1% (150,000 ha)	5% at elevations less than 400m in 40 years	60,000 ha. 1500 each year
Flanders part of Belgium	10.8% (728,000 ha)	Positive strategies but no long term number found	13,665 ha
The Netherlands	11% (375,000 ha)	75.000 ha new forest starting 1992	75,000 ha
North East France	In the region: 8-10%. At the national level: 27% (15,341,000 ha)	The cover is growing but no specific goal has been stated	n.a.

Source: Nielsen and Jensen (2007). Modified by the author.

In the time period between 1992 and 1997, on average 60% of the trees planted were broadleaved, mixed plantation (with more than two thirds of broadleaved) or fast-growing plantation. Beside the fact that the incentives for planting broadleaves where 25% higher than the ones for planting conifers, afforestation of former farmlands with broadleaved species is often seen as a preferable alternative to conifers from an ecological and social point of view (Valkonen, 2008). In other words, broadleaved forests are generally thought to be crucial to preserve forest biodiversity and offer an attractive environment for recreational purposes and tourism (Löf *et al.*, 2004).

In this context, oak became widely used for afforestation in many parts of Europe (Jensen and Skovsgaard, 2009). In Denmark, for instance, the area covered by oak increased by approximately 40% during the 1990s. It was estimated that oak forests cover an area of about 43,000 ha, representing 9%

of the total forest area in year 2000. The importance of oak is increasing also in Southern Sweden (Löf *et al.*, 2004), Finland (Valkonen, 2008) and, in general, in the nemoral urban woodland (Gundersen *et al.*, 2005). The development of the agricultural policy at the European and national level suggests that this trend is expected to continue, further reinforcing the significance of oak in forests and landscapes.

1.2 New challenges for silviculture and landscape planning

The increase of the forest area raised new questions to landscape planners, foresters and researchers related with social and environmental sciences from all over Europe. Issues related to ecology (Zanchi *et al.*, 2007, section 4), hydrology (Wattenbach *et al.*, 2007), soil composition (Vesterdal *et al.*, 2002; Rosenqvist, 2007), social sciences (Madsen, 2003; Kassioumis *et al.*, 2004; Nielsen and Jensen, 2007; Marey-Pérez and Rodríguez-Vicente, 2009), landscape planning (Karjalainen and Komulainen, 1998; Tyrväinen *et al.*, 2006), rural and forest policy (Marey-Pérez and Rodríguez-Vicente, 2009) as well as silviculture (Rey Benayas, 1998; Ammer, 2000; Daugaviete, 2000; Löf *et al.*, 2004; Valkonen, 2008; Ovando *et al.*, 2010) were widely discussed.

The circumstances and the consequences of afforestation schemes were different across the continent due to differences in climate, landscape, culture and economy. Therefore, distinct silvicultural and landscape planning questions were debated across Europe. For example, in the Mediterranean Europe the afforestation took place mainly in marginal lands. There, the main research objectives were focused on the establishment and tending of new forests in order to cope with soil erosion, soil degradation as well as enhance the timber production to create complementary income sources for farmers in remote areas (Kassioumis *et al.*, 2004; Ovando *et al.*, 2010).

Timber production was the main reason for afforestation, mostly of Norway spruce (*Picea abies* (L.) Karst.) in the densely forested Scandinavian countries like Sweden and Finland (Rosenqvist, 2007). In this case, as underlined by Karjalainen and Komulainen (1998), one of the main issues emerged was that rural landscapes represent a “scarce” resource and often they symbolize the historical process of settlement and cultivation. Given that afforestation modified rural landscapes by hiding their characteristic elements, the research objectives were focused on planning the afforestation in a way that reduces the negative impact for the local residents.

A third different picture was observed in the scarcely forested North-western part of Europe. In this master thesis the focus was on Denmark, but analogous situations could be observed for instance in Belgium (Roovers *et al.*, 2002; Van Herzele, 2006). According to Madsen (2003), under the Danish afforestation program, afforestation incentives were bounded to the fulfilment of three main goals: to protect groundwater resources, to ensure urban recreational needs, and to support and enhance biological diversity in the landscape. For this reason, many public and private farmland afforestations took place close to urban areas in order to increase the potential for recreational services. As a result, in a setting of increasing urbanization (Konijnendijk, 2000, 2003; Ode and Fry, 2002) forest was brought close to the citizens, offering an environment for leisure activities and facilitating the contact with nature.

In this context, the objectives of forest management are becoming increasingly diverse, raising new questions to silviculture (Jensen and Skovsgaard, 2009). Two major forces are pushing these changes: on one hand, the advent of the sustainable forest management and multiple use forestry paradigms; and to the other, the process of "citification" of the forest (Paris, 1972; Konijnendijk, 2000). To put it more simply, forests have to meet the society's new needs: not only to assure timber supply, but also fulfil the recreational requirements of the people and respond to the society demand for protecting biodiversity, among others. The conventional forest management, focused merely on timber production, may not be always appropriate to respond to the new objectives.

An example is given by the traditional oak management applied to new urban or periurban forest in Denmark. Young stands managed according to the traditional paradigm are generally very dense, and precommercial thinnings are carried out to promote the long-term economic potential of the stand, giving little consideration to other management objectives like forest recreation or biodiversity. A rethinking of young stand treatment is then becoming necessary. This is going to be relevant not only for Denmark, but also for the Central and Northern Europe (if not for whole Europe). As a matter of fact, almost 50% of the area stocked with hardwood in urban woodland in the nemoral zone, and even more in the boreal zone, has an age lower than 49 years old and a consistent part of this is likely to be represented by young stands (Figure 3).

Given the intensification of the level of connectivity between urban society and forests, the risk of conflicts increased. Conflict situations occurred between the traditional (industrial) and the "new" uses of forests. This type of contrast was more evident in case of felling operation or thinning; however,

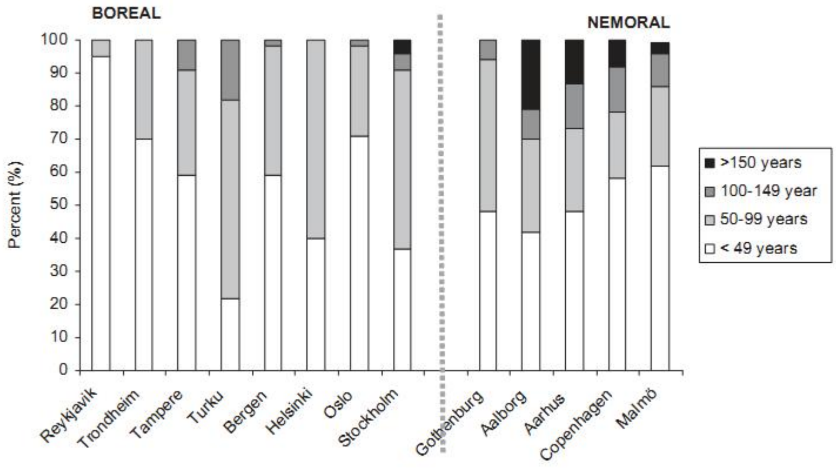


Figure 3: Present age structure of hardwoods in the urban woodlands by area as reported by the responding managers. Source: Gundersen *et al.* (2005).

in recent years due to intensive afforestation it involved also young stand management operations.

Professionals' and the general public's preferences and values about forests were compared in some studies in order to identify areas of conflicts and reduce their risk (Jensen, 1993; Winter, 2005; Bradley and Kearney, 2007; Beckwith *et al.*, 2010). Results indicated that the similarities between experts and the general public were more than the differences, although there is still an area of misperception in several subjects investigated. As clearly analyzed by Konijnendijk (2000), the urban population is unfamiliar with the (natural, rural) production cycle. To put is more simply, forest managers have to deal with a society with a less understanding for their management actions but still ready to challenge the foresters' professional authority.

Thus, forest managers have to use an adequate long-term perspective, find the appropriate silviculture measures to produce wood and non-wood products as well as environmental, cultural and social services. The work of this thesis is oriented to understand the needs of the society and translating them into silvicultural practices. Questionnaires to investigate the preferences of the populations are often used for this purpose. There is an extensive literature on this topic, of which a brief summary is presented in Section 1.4.

Finally, as pointed out by Nielsen and Jensen (2007) and Jensen and Skovsgaard (2009), changing socioeconomic and market conditions represents further challenges to traditional silvicultural methods: in particular, the increased cost of labour, the progressive reduction of personnel, and the unstable or scarce management budget respectively for the public and private ownership. These issues affect especially management operations in the first part of the rotation, such as establishment and precommercial thinning, that are highly dependent on manual labour and do not generate any short-term return. As a consequence, there appears to be a need for a rethinking of thinning practices in young stands towards more simple and schematic approaches.

1.3 The traditional management practices for young oak stand in Denmark

According to Rune and Skovsgaard (2007) and Jensen and Skovsgaard (2009), the traditional management of oak in Denmark is oriented to wood production. This is achieved through the establishment of even-aged pure stands, often with an understorey of other tree species. The establishment is usually done by planting or sowing. In the first case, approximately 3500–5000 bare-rooted seedlings are planted per hectare (Löf *et al.*, 2004). The tree density varies depending on provenance, site and possible nurse trees. In the case of sowing, the initial density is significantly higher.

Oak is a light demanding species and stands young are very dense. Therefore, precommercial thinnings are required to reduce stocking and concentrate growth on crop trees. In production forestry, precommercial thinnings are normally carried out by skilled forest workers equipped with brush-saws. The management model for young oak stands is based mainly on results from a precommercial thinning experiment implemented in the early 1900s (Hauch 1908, 1915, *in* Jensen and Skovsgaard, 2009). The aim of the experiment was to investigate silvicultural actions in young stand to favour growth as well as the wood quality of potential crop trees. The recommendations suggest thinning among dominant trees to remove undesirable individuals combined with heavy thinning among socially intermediate trees, while retaining an understorey of suppressed oak trees. Three to four pre-commercial thinnings should be carried out to achieve a stem number of 2200 trees per hectare at an age of 20 years. The stem density after the first precommercial thinning should be in the order of 5500–5000 stems per hectare. This model is the most applied for producing high-quality timber in good moraine sites, and it is kept as a reference in less optimal site conditions. The first commercial thinning is carried out when the volume of merchantable products is sufficient to ensure neutral or positive revenue.

In summary, the traditional silvicultural practices for young oak stand are focused on developing and enhancing the economic and productive potential of the stand with the result that little weight is assigned to other management objectives (Jensen and Skovsgaard, 2009).

1.4 Investigating visual preferences on forest recreation

Forest recreation is strictly connected with scenic beauty. The interrelations between the aesthetic, the beauty as well as the pleasantness of the environment and soul and body "re-creation" have been discussed at least since the Greek and Roman times. The *locus amoenus*, Latin for "pleasant place", was intended as a place characterized by open woodlands, sometimes with a brook, recalling the biblical Eden. This concept can be traced back to the Greek poet Homer. It became a cornerstone of pastoral works of poets such as the Theocritus (3rd century BC) and later Virgil (Publius Vergilius Maro, 70 BC–19 BC). The latter wrote in *Ecogla I* of *Bucolics*:

> *"Tityre, tu patulae recubans sub tegmine fagi*
> *silvestrem tenui Musam meditaris avena*
> *nos patriae fines et dulcia linquimus arva:*
> *nos patriam fugimus; tu, Tityre, lentus in umbra*
> *formosam resonare doces Amaryllida silvas*[1]. [...]"

Moreover, the assessment of scenic beauty or visual aesthetic beauty has been a concern for human for as long as sites have had to be selected for living or traveling, although other primary needs (i.e. food resources, security, etc.) have been more important (Daniel, 2001). However, it is only in the 1960s when the assessment of scenic beauty started to be done in a systematic and formal manner. At that time, the analysis of visual aesthetic beauty or scenic beauty was developed and implemented in many field connected with environmental management.

[1]"You, Tityrus, 'neath a broad beech-canopy / reclining, on the slender oat rehearse / your silvan ditties: I from my sweet fields, / and home's familiar bounds, even now depart. / Exiled from home am I; while, Tityrus, you / sit careless in the shade, and, at your call, / "Fair Amaryllis" bid the woods resound." Translation by Greenough (1900), accessed on April 17, 2011, on http://www.perseus.tufts.edu/.

The scenic beauty assessment is included in a broader field of study called "landscape perception" research. Its final research orientation centres on the human-landscape-interaction-outcome model (Zube *et al.*, 1982). Four different approaches can be identified: the expert (or design) approach, the psychophysical approach, the cognitive (or psychological) approach and the phenomenological approach (Zube *et al.*, 1982).

The expert approaches are based on the assumption that trained professionals can objectively analyze and translate the landscape features into formal parameters according to the principles of art, design, ecology or management (Konijnendijk, 2003). In this case, the landscape quality and scenic beauty can be reached via wise management techniques.

In the psychophysical paradigm, the general public or selected populations are involved as passive observers. The visual characteristics of the environment (such as amount of slash on the ground, basal area, stem density, canopy density) are initially measured. Then, it is asked to the observers to evaluate the visual quality of the landscape. The stimuli can assume several forms such as on-site visits, photographs, verbal stimuli, digital image editing, visual landscape simulations or a combination of them, each one with different degrees of accuracy. The stimuli evaluation is done through a single psychological response such as scenic beauty or visual aesthetic quality. Finally, the responses are analyzed and associated to the measured landscape elements by the means of statistical analysis in order to extract the landscape preferences (Konijnendijk, 2003; Zube *et al.*, 1982; Daniel, 2001).

The cognitive approach, following the definition of Zube *et al.* (1982), involves a search for human meaning associated with landscapes or landscape properties. The information received by the human observer from the landscape are elaborated by the means of experience, future expectation, and sociocultural conditioning. The interaction between the observer and the landscape lends meaning to landscape as a whole such as mystery, prospect, refuge, and hazard. The cognitive approach tries to explain the relationship between landscape preferences and such meanings in order to investigate the psychological basis of landscape preferences (Konijnendijk, 2003).

The phenomenological approach is focused on the interaction between the landscape and the human, the latter considered as an active participant. The main objective of this research is to study the total experience of the individual interacting with the landscape (Herzog, 1985, *in* Konijnendijk, 2003) and not the comparative assessments between different landscapes (Konijnendijk, 2003).

Now, the aim of this work is the analysis recreational preference according to different silvicultural treatments in young oak stands. In abstract terms, the scope is to explore *public preferences* on *aesthetic quality*, assuming that recreational preferences are related to the visual qualities of the stand. As described above, in the literature there are two main paradigms for evaluating the visual aesthetic beauty of a landscape: the expert approaches and the psychophysical approach. Both types of approaches share the basic concept that landscape quality derives from the interaction between humans and landscape, that is, between the properties of the landscape and the effects of those properties on human visitors (Zube *et al.*, 1982; Daniel, 2001). However, of these two, only the psychophysical approach can be considered as a "public preference" research because the expert approach does not include any analysis of the people's opinions.

In addition, according to Daniel (2001), the psychophysical approach has achieved higher levels of reliability compared to the expert approach in the analysis of scenic beauty. Jensen and Koch (1998) estimated that the experts' opinions do not match the public preferences in almost one third of the cases investigated. Moreover, during the last two decades, the implementation of this approach became more flexible especially when related with visual stimuli; relevant developments were carried out in the field of digital image processing, computational procedure, landscape simulation and communication technology. Therefore, nowadays very detailed visual stimuli can quickly reach the observers almost everywhere and they can be easily understood.

In light of these facts, the psychophysical approach is the most used paradigm for deriving measurement of scenic beauty. It has been applied world wide - from America, to Europe, Asia and Oceania - in many field of environmental management. Examples are numerous in landscape planning (Zube *et al.*, 1982; Tips and Savasdisara, 1986a,b; Daniel, 2001); agriculture and rural management (Arriaza *et al.*, 2004; Rogge *et al.*, 2007), coast and rivers management (Banerjee, 1977; Byrne, 1979; Hali, 1974; Stein, 1979; *in* Zube *et al.*, 1982).

This approach has been adopted in a large number of work concerning forests, of which Ribe (1989) presented a detailed review. As already discussed, the growth of the multiple use forestry paradigm has increased the attention to recreational services and the public perception of managed forests. Moreover, the traditional belief that a well-managed forest should lead to high scenic quality has been questioned, demanding for new methods to define visual aesthetic beauty in forestry (Ribe, 2002). As a result, the focus of the scenic beauty assessment in forests has shifted from the landscape level (Patey and Evans, 1979) to the stand level analyzing the effects of different silvicultural practices. Examples can be find in Daniel and Boster (1976), Brown and Daniel (1984), Ribe (1989), Jensen and Koch (1998), Karjalainen and Komulainen (1998), Nielsen and Jensen (2007) and Hoffman and Palmer (1996). Gundersen and Frivold (2008) made a review of public preferences for forest structures in Fennoscandia.

Although all the studies mention above deal with forest scenic beauty, some contributions focus explicitly on particular aspect of forest aesthetic: urban wood management (Ode and Fry, 2002; Tyrväinen *et al.*, 2006) and forest recreation (Brunson and Shelby, 1992; Jensen and Koch, 1998; Jensen, 1999; Shelby *et al.*, 2005; Jensen and Skovsgaard, 2009; Beckwith *et al.*, 2010). These two aspects are strictly connected because, according to Van Herzele (2006), urban and periurban woodlands are widely seen as the best strategy for providing green spaces for recreation.

However, scenic beauty does not represent the only variable influencing recreational preferences, although it is one of the most important (Virgil *docet*). As showed by Shelby *et al.* (2005), recreational ratings are related to, but different from scenic ratings. For example, it is likely that a clearcut has a low scenic beauty, however for a berry picker it might have a high recreational potential (Ribe, 1989). Therefore, in some studies such as Brunson and Shelby (1992), Jensen and Koch (1998), Jensen (1999), Shelby *et al.* (2005), recreation quality (related to specific activity) and scenic quality are analyzed separately.

Furthermore, it is possible to study recreational preferences with several other tools deriving from the economic analysis. For example, the conjoint analysis, the travel cost method or the willingness to pay method (Sayadi *et al.*, 2005; Roovers *et al.*, 2002; van Rensburg *et al.*, 2002). In this work, however the data does not allow to group the respondents accordingly to their recreational activities, so the focus is on the visual preferences. The recreational preferences that are not connected to visual quality, as well as methods to to extrapolate preferences alternative to the psychophysical approach will not be further discussed.

Although for much of the population's preferences for forest scenes vary in a similar pattern, preferences for certain scenes may differ based on a person's relation with the landscape or with certain characteristics of the respondents. For example, a forest scene that has been significantly modified by a timber harvest might be rated higher by a person working in forestry than by a person who does not work in forestry (Bradley *et al.*, 2004). For these reasons, visual aesthetic preferences have been analyzed in relationship with residential environment and macro-geographical environment (Tips and Savasdisara, 1986a); gender, age, income and religion (Tips and Savasdisara, 1986b); as well as professional background (Rogge *et al.*, 2007; Jensen, 1993; Jensen and Koch, 1998; Winter, 2005; Bradley and Kearney, 2007).

1.5 Previous studies on recreational preference in young stands

As already discussed, given the recent waves of oak afforestation in proximities of urban areas in Denmark, there is a number of young stand, in particular stocked with oak, which requires a rethinking of the traditional practices. Nielsen and Jensen (2007) underlined the need for combining visual aspect and technical considerations. This was then investigated by Jensen and Skovsgaard (2009), who analyzed the preference for forest recreation of the Danish adult population in relation to young penduculate oak (*Quercus robur* L.) stand treatments. The study was based on five pairs of color photographs of even-age oak stands, each pair representing a different thinning intensity in a 13-year old experiment: 7000 stems ha^{-1} (unthinned control plot), 5300 stems ha^{-1} (traditional precommercial thinning), 1000 stems ha^{-1}, 300 stems ha^{-1} and 100 stems ha^{-1}. All cut trees were left on the ground after the thinning operation.

The authors investigated how the general Danish population ranked these alternative precommercial thinning practices based on the criterion "Which forest environment do you prefer as a visitor?" The study was carried out as a national survey representing the Danish adult population. The pictures together with a questionnaire were sent by post; overall, 243 questionnaires were sent and the response rate was 73%. The same photographs and questionnaire were used for this work and they are described in details in Chapter 2 .

Jensen and Skovsgaard (2009) found out that visitor accessibility seemed to be considered as a crucial characteristic for the general visitor. Thinning slash could be pointed out as a major factor for the impression of accessibility. The indications for silvicultural practices suggested that the general public prefers low to mid-range densities (300-5300 ha^{-1}) over very dense (7000 ha^{-1}) or very open (100 $^{-1}$) stands. Moreover, the authors believed that with opportune silvicultural measures, such as high pruning for the selected crop trees and extremely heavy thinning around a few individual trees of inferior wood quality, it might be possible to fulfil the multiple management objectives (production, recreation and biodiversity protection). The stand will result in a mixture of timber oaks and large-crown open-grown trees.

Studies on the management and silviculture of young stands were carried out also in North America and Australia (Findley *et al.*, 2001; Bradley *et al.*, 2004; Beckwith *et al.*, 2010). Although the specific silvicultural recommendations are not applicable in Europe due to differences in species composition, forestry tradition, economic and social situation, the author believe that some general results (i.e. the effects on scenic preferences of the affiliation to forestry, demographic variables, among others) and methodologies are relevant for this thesis work.

Bradley *et al.* (2004) investigated several silvicultural options to be applied to young-growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) forest in western Washington (USA) managed for multiple objectives. The analysis considered six management options aiming to create different age and canopy structures. The study was part of a broader investigation that ranged from production and economics, to ecology and, of course, social aspects (aesthetic effects and public acceptance).

As far as the recreational preferences are concerned, Bradley *et al.* (2004) formulated a survey containing 30 colour photographs depicting the six treatments in the study. For each treatment, five photos were taken at different point in time: one before the final harvesting (representing the final stage of the treatment), one in the first spring after the harvesting operations and the others in each spring of the following 3 years. Respondents were asked to rate the pictures on a 1 to 5 scale according to how much they liked the scene. Beyond the photo portion of the survey, there were four pages of questions regarding knowledge and opinions about forest management, demographic information affiliations with natural resource or environmental organizations. Overall, approximately 750 questionnaires were sent and 210 individuals responded (response rate 28%). The authors grouped the interviewees into subgroups: general public, foresters, recreationists, environmentalists, and educators.

The main findings of Bradley *et al.* (2004) showed that in general foresters tended to show significantly greater preference than most other groups for treatments where moderate to large openings where present (i.e., clear-cuts, patch cut, and group selection). All groups showed high preference for the repeated thinning and for the control treatment, although foresters rated the latter much lower than environmentalists and educators. Finally, the authors underlined that, in general, respondents did not discriminate among the scenes based on treatment type; rather, the interviewees tend to group scenes according to similar overall patterns of openings, tree size variation, and colour.

Beckwith *et al.* (2010) presented an extensive report on the impact of forest thinning on perceptions of recreational value and forest health in the forested catchments of the South West of Western Australia. In the study, five thinning programs were tested. The treatments differ for basal area, thinning method and regrowth control. A "no treatment" option was also considered. For the analysis, the authors generated computer photo simulations of forest scenes. Each photo simulation consisted of a sequence of five images per treatment representing the first year after treatment, and then 5 years, 25 years, 50 years and 70 years after treatment. In the questionnaires for each treatment, respondent had to rate the acceptability of each image in terms of three attributes: forest health, scenic beauty and outdoor recreation suitability. The questionnaires with the photo were sent to three groups of interest: bush-walkers, off-road cyclists and professional forest or water resource managers selected from local organizations. In total, 203 questionnaires were returned to the researchers.

An important finding of this study was that after viewing the temporal sequences of forest images (and not only the image after the treatment), the acceptability ratings of the bush-walker and cyclist groups moved closer to those of the manager group. As far as the preference of treatment is concerned, all groups preferred the no treatment option. The thinning method was the most important element in shaping the respondent preferences for forest scenes. In contrast with the work of Bradley *et al.* (2004), respondents with a background in silviculture presented analogous forest visual preferences to those of other respondents. Moreover, the demographic variables age, gender, place of residence or level of education were not predictors of forest scene preferences. Once again, from the analysis it was clear that forest density, and hence stand accessibility, was the most important element to determine the scene's acceptability for forest recreation.

1.6 Aim of this study

The aim of this study was to analyze the recreational preferences for different thinning practices in young penduculate oak stand. The analysis was structure on three levels. The first level was focused on the Danish population only. The recreational preferences of the general public, natural resources students and forestry professionals were compared. The other two levels, instead, aimed to examine recreational preferences across Europe. Specifically, the second level was focused exclusively on an international comparison of forestry professionals, whereas the third on natural resources students.

The study tried to answer to the following questions:

- Are the responses from Danish forestry professional, Danish natural resources student and the Danish general public different?
- Is it possible to find some patterns in the opinion of natural resources students across Europe? And among forestry professionals?
- The study is focused on different young stand treatments. To which extent is the Danish population able to distinguish among treatments? And professionals and students? Are there some others undergoing factors explaining recreational preferences?

With the first question, the main idea was to see whether the "experts"' opinion is enough to shape the management in a way that it could include the population recreational preferences or, alternatively, survey methods should be used to create a forest environment that are suitable for recreational purposes. The second point addressed the question whether there is a difference in perception of the recreational preference across Europe. This research on international differences in recreational preferences could be relevant especially in urban woodland management, in the light of the sociocultural integration process undergoing in Europe (Konijnendijk, 2000, p. 89). Finally, through a principal component factor analysis, it was investigated whether distinct treatments were perceived differently by the subgroups and eventually which undergoing factors were influencing recreational preferences.

2 Materials and methods

2.1 The study area

The study area used for this thesis work is the same selected by Jensen and Skovsgaard (2009) for their investigation of the Danish general public recreational preferences in young oak stands. It is located in the Haslev Orned forest at Bregentved Estate, approximately 60 km south of Copenhagen (Rune and Skovsgaard, 2007; Jensen and Skovsgaard, 2009, UTM coordinates, ETRS89, zone 32: E 689,290 m, N 6,135,994 m, height above sea level 33 m). The site, called experiment no. 1516, is one of the three replications of a Danish experiment on precommercial thinning of oak.

The stand description that will follow is based on Rune and Skovsgaard (2007) and Jensen and Skovsgaard (2009). The study area is composed of even aged pedunculate oak (*Quercus robur* L.) with a sparse admixture of hornbeam (*Carpinus betulus* L.). The stand establishment was carried out in 1989. Approximately 90–95 kg ha^{-1} of penduculate oak acorns were sowed on a former meadow during spring. Acorns were of local provenances from stands of Dutch origin (seed sources F.661 and F.630). To protect the newly established stand from browsing, the area was fenced for about ten years.

When the stand was 13 years old (spring 2002), experiment 1516 was installed. At that time, the stem density varied from 6000 to 11000 stem ha^{-1} and dominant top hight was 6 to 7 m. The aim of this experiment and of the other two replications is to quantify short and long-term effects of precommercial thinning in even-aged oak in relation to different issues such as volume growth, wood quality, biodiversity and recreation. The experiment comprises eight treatments with different combinations of precommercial thinning grade and timing. All treatments were replicated twice within experiment 1516.

Five treatments were selected for this study: a unthinned control treatment (with self thinning only) and four treatments with different thinning intensities. Treatments are described in terms of residual stem densities: 7000 stems ha^{-1} in the "unthinned" control plot; 5300 stems ha^{-1} in the "traditional precommercial thinning" plot; 1000 stems ha^{-1} in the "heavy precommercial thinning" plot; 300 stems ha^{-1} in the "very heavy precommercial thinning" plot and 100 stems ha^{-1} in the "solitary trees" plot. All cut trees were left on the ground after the thinning operation. The unthinned control plot included an additional 1900 dead stems ha^{-1} (with a height larger than 1.3m), most of which were still standing.

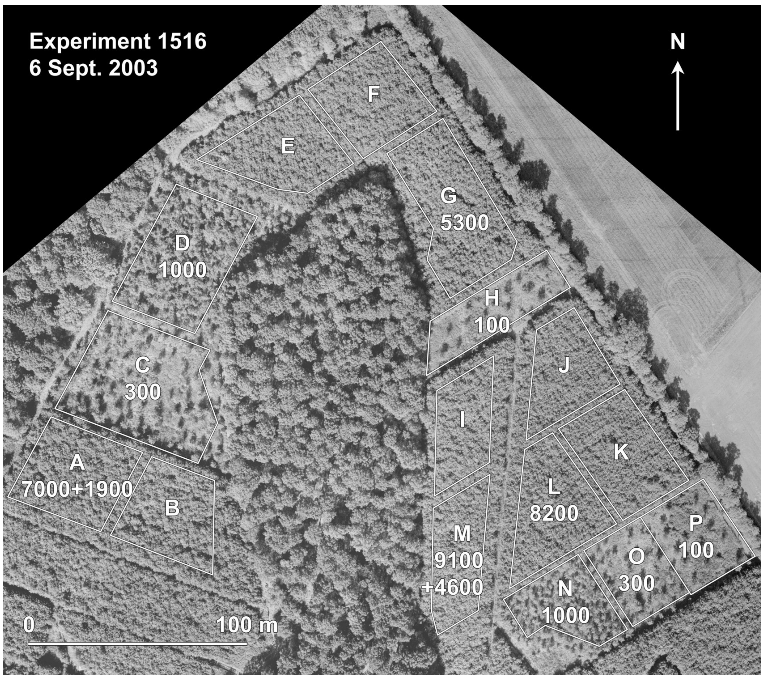


Figure 4: Aerial photograph of experiment no. 1516 taken on 6 September 2003, two growth seasons after the first precommercial thinning. Indications of plot borders, orientation (UTM grid) and scale of measurement are only approximate (Source: Jensen and Skovsgaard, 2009).

Figure 4 presents the spatial allocation of treatments in experiment 1516. In this aerial photographs, taken two growth seasons after the first precommercial thinning, plots are bordered by white lines and identified by plot ID (letters A, B, etc.) and residual stem number. For plots A and M, representing the unthinned control treatment, the number of dead stems still standing is indicated after the plus sign. Plots without an indication of stem number are reserved for treatment at a later stage and therefore not included in the study.

2.2 Photographs of the experimental plots

The ten pictures taken by Jensen and Skovsgaard (2009) were used in this study. Each treatment was depicted in two pictures. The first picture was obtained in order to show the row-wise structure of the stand and the second picture tried to depict the lack of such structure. The pictures are presented grouped by treatments in Figures 5–9. In Figure 10, the map of experiment 1516 is presented. Yellow dots indicate the points from which pictures were taken, with the exception of picture 217 that was taken from plot P. In the stands, these points are permanently marked with yellow pales (with exception of plot P).

The ten pictures were taken in August 2002, shortly after the thinning operation had taken place. According to Bradley *et al.* (2004), taking the photos in the spring or summer minimizes the factors that may influence preference ratings such as fall colour, snow, or bare trees.

Jensen and Skovsgaard (2009) assigned a three-digit identification number to each picture. The first digit was added to reduce the chance of the numbering affecting the assessment. The tree digit number was printed on the top-right corner of each picture. The ten pictures were printed in a 10 × 15 cm format.

2.3 Questionnaire surveys and data acquisition

Recreational preferences were investigated through a questionnaire survey with attached the red envelope with the ten pictures. In the short questionnaire, the respondent was asked to rank the pictures according to the criterion: "Which forest environment do you prefer as a visitor?" Moreover, the respondents had to answer to other six general questions dealing with number of forest visits, affiliation to forestry or other "green" occupation, childhood environment, age and gender. The questionnaire was written in Danish and translated in English and Italian. The English version can be found in Appendix A.

The data acquisition was carried out in different periods and with different target groups. A first wave of data acquisition was conducted by Jensen and Skovsgaard from November 2004 to January 2005 as national survey based on postal questionnaires. Respondents represented the resident population in Denmark above 15 years of age, with a slight over-representation of females. Overall, 243 individuals responded to the questionnaire, with a response percentage of 73%. These data were used by Jensen and Skovsgaard (2009) in their study. More details on the survey's methodology can be found in that paper.

In the second wave of data acquisition, the same questionnaire and set of pictures were used to survey forestry professionals and students. The questionnaires were distributed during several seminars and conferences in Eu-

(a) *In the direction of rows.* (b) *Across the direction of rows.*

Figure 5: Unthinned control, (*7000 stems* ha^{-1} + *1900 dead* ha^{-1})

(a) *In the direction of rows.* (b) *Across the direction of rows.*

Figure 6: Traditional thinning, (*5300 stems* ha^{-1})

(a) *In the direction of rows.* (b) *Across the direction of rows.*

Figure 7: Heavy thinning, (*1000 stems* ha^{-1})

(a) *In the direction of rows.*

(b) *Across the direction of rows.*

Figure 8: Very heavy thinning, (*300 stems ha*$^{-1}$)

(a) *In the direction of rows.*

(b) *Across the direction of rows.*

Figure 9: Solitary trees, (*100 stems ha*$^{-1}$)

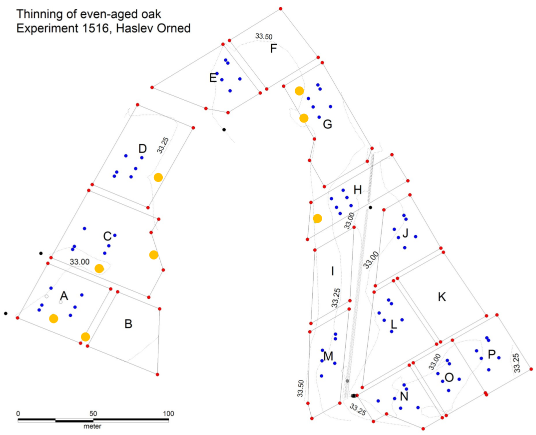


Figure 10: Map of experiment no. 1516. Red dots represent the plots' vertexes, yellow dots show the marked points from which pictures were taken, blue dots denote ground flora measurement areas (Source: Attocchi (2011), modified by the author).

rope as well as during field excursions, including field tours to the experiment 1516, in the period between 2004 and 2005. During field tours to experiment 1516, the questionnaires were filled in before the visit in order to guarantee the same type of stimulus for all respondents (pictures) and not to introduce bias in the analysis. In total, 330 professionals and students from Denmark as well as several other European countries were interviewed via the questionnaire.

In winter 2011, the second wave dataset was preliminary analyzed by the author. Given that the survey of experts had been collected without a precise experimental design, the need for a third wave emerged in order to balance the number of professionals or students among countries. The aim was to have approximately the same size in the respondents' groups and a homogeneous cover of Europe. Therefore, questionnaires and pictures were sent during Spring 2011 by mail to several forest faculties in Europe. Respondents were mostly forestry students from Sweden, Portugal, Wales and Austria, however few tens of forestry professionals from Northern Italy and Portugal were also surveyed. Overall, 152 questionnaires were collected in this third wave.

In the time span of approximately 6–7 years between the second and the third wave, there might have been changes in people preferences. However, according to the author opinion, this does not constitute a problem for the analysis. The undergoing hypothesis is that within such time span recreational preferences are thought to remain quite stable and therefore data can be considered as if they were collected simultaneously. This hypothesis is confirmed by several studies that show that recreational preferences showed only minor changes in a twenty-year period (Jensen, 1999; Lindhagen and Hörnsten, 2000).

2.4 The three datasets

Once the three waves of the survey had been collected, each respondent was classified in one of the following categories: general public, forestry professionals, "other green" professionals (employed in landscape planning, horticulture, agriculture, nature administration, or similar), other professionals, or natural resources students. To assign respondents to one of these groups, information about affiliation to forestry, affiliation to "other green" job, age as well as the occasion in which the questionnaire were distributed were used. Some overlaps were detected, mostly students who also had an affiliation with forestry or "other green" jobs (summer jobs or similar), or respondents with both forestry and “other green” job experiences. In the former case, the age of the respondent was used to discriminate among students and professionals with a cut-off level for student set at 35 year. In the second case, the presence of a forestry affiliation was considered a sufficient condition to label the respondent as forestry professional. The hypothesis made here is that a forestry education or experience somehow influences the perception of the forest environment. In other words, the silvicultural knowledge (typical of forestry professionals) offers a key to understand and analyze the forest environment that is likely to affect the respondents’ opinion.

Given the high heterogeneity of the data, the analysis was then subdivided in three parts. The first part was based on a dataset containing only the Danish population data. Denmark was the only country surveyed where it was possible to compare forest recreational preferences of the general public and experts. The second and the third part were based on datasets containing respectively data on forestry professionals and on natural resources students from several European countries. Unfortunately, no data were available to compare the general public across Europe.

Table 2 shows the structure of dataset no. 1 focusing only on respondents from Denmark. As underlined by Jensen and Skovsgaard (2009), the general public segment is representing the adult general population, whereas the other segments (forestry professionals, “other green” professionals, other professionals and students) were not tested for their representativity of the overall population of experts. Still, for the way the data have been collected (conferences, field tour, etc.), it is believed that the experts’ segments can offer a sound indication of the professionals and students’ recreational preferences. In the analysis the segments “other professionals” was not used because of its small size.

Table 3 shows dataset no. 2 used to analyze forestry professionals’ recreational preferences across Europe. In this case, only respondents labelled as forest professionals were filtered out. Overall, 152 forestry professionals were selected. Given the low number of respondents per country and their scattered geographical distribution, respondents with different nationalities were grouped together according to the geographical region in which their countries belong. In Table 4, the countries forming each region are listed. Denmark was kept separated for two reasons: firstly, because it represents a benchmark and a point of reference between the European forester analysis and the Danish population analysis; secondly, because given the high number of foresters from Denmark, recreational preferences of the Nordic

Table 2: Dataset no. 1 representing respondents from Denmark (segments' size and percentage).

Occupation	Freq.	Percent
Forest professionals	59	15.2
Other green professionals	23	5.9
Natural resources students	53	13.6
Others professionals	11	2.8
General public	243	62.5
Total	389	100

countries cluster would have been strongly influenced by including also the Danish forestry professionals. The allocation of Italy between the Central European countries might be questioned because geographically it is located in the southern part of Europe. However, all respondents from Italy live and work in the Northern part of the countries, in the Prealpine and Alpine region. Therefore, the landscape and vegetation types they are used to are closer to the ones found in Austria rather than Portugal. Moreover, the Italian silviculture in the Northern part of the country is influenced by the German school. As a consequence, it appeared to be more consistent to group Italy (labelled as "Northern Italy" for clarity's sake) with the Central European segment.

Table 4 presents the dataset created for the analysis of natural resources students across Europe. In this case, five countries were selected for representing different European regions: Sweden for Northern Europe, Portugal for Southern Europe, United Kingdom for non-continental Europe, Austria and Romania for Central and Eastern Europe. In addition, Denmark was included as a benchmark. The choice of using representative countries and not cluster of countries from different parts of Europe depended on the fact that data about students presented countries with a high number of observations (the ones selected) and other countries with just few respondents. Consequently, each cluster would have been strongly influenced by one country only.

Table 3: Dataset no. 2 representing forestry professionals grouped by geographical macro regions (segments' size and percentage).

Country group	Freq.	Percent
Denmark	59	38.8
Other Nordic countries	30	19.7
Finland	*6*	*(20.0)*
Faroe Islands	*1*	*(3.3)*
Iceland	*5*	*(16.7)*
Norway	*10*	*(33.3)*
Sweden	*8*	*(26.7)*
Central Europe	27	17.8
Austria	*1*	*(11.1)*
Belgium	*1*	*(3.7)*
Czech Republic	*2*	*(7.4)*
Germany	*3*	*(11.1)*
France	*2*	*(7.4)*
Northern Italy	*12*	*(44.4)*
Poland	*2*	*(7.4)*
Romania	*2*	*(7.4)*
Southern Europe	17	11.2
Former Yugoslavia	*1*	*(5.9)*
Greece	*2*	*(11.8)*
Portugal	*13*	*(76.4)*
Spain	*1*	*(5.9)*
Non-continental Europe	19	12.5
United Kingdom	*16*	*(84.2)*
Ireland	*3*	*(15.8)*
Total	152	100

Table 4: Dataset no. 3 representing natural resources students by country (segments' size and percentage).

Country	Freq.	Percent
Austria	46	16.9
Denmark	53	19.5
United Kingdom	38	14.0
Portugal	46	16.9
Romania	53	19.5
Sweden	36	13.2
Total	272	100

2.5 Assessment of photographs

In Section 1.4 the visual preference investigation framework has been introduced. Within the psychophysical paradigm, there is a rather numerous set of suitable stimuli that can be used, such as on-site visits, photographs, verbal stimuli, digital edited images, visual landscape simulations. In the last decades, there has been a conspicuous literature reviewing methods of measuring preferences of different forest and landscape types (e.g. Zube *et al.*, 1982; Jensen and Koch, 1998; O'Leary and McCormack, 1998; Daniel, 2001; Karjalainen and Tahvanainen, 2002).

The choice of photographs as the appropriate stimulus for the measurement of visual preferences is supported by several considerations. First, as Kaplan and Kaplan (1989) suggested, the use of images compared to in situ visits poses no serious problems. Limitations of photo based judgments compared to field observations were discussed by Hull and Stewart (1992) and Stewart *et al.* (1984). Nevertheless, despite some bias observed at the individual level, average on-site scenic beauty assessments were similar to the average photo-based assessments (Hull and Stewart, 1992). Second, according to Tahvanainen *et al.* (2001), preconceptions concerning different silvicultural measures did not consistently correspond to perceptions based on the assessment of visual images. In other words, the use of a mere verbal stimulus is critical because, without illustration, people may create different mental images about the proposed management actions. Third, besides that both black-and-white and colour photographs can provide a basis for fully valid measurement of visual preference (Jensen and Koch, 1998), they also offer the advantage of cost effectiveness. As a matter of fact, picture assessment (compared to filed observation or simulation analysis) provides as much information as possible at a reasonable cost (Bradley *et al.*, 2004). For instance, it is relatively easy to reach a large sample of the population of interest and to submit to respondents scenes from different places or times of the year, at one and in a single interview. Fourth, photograph stimuli require insignificant background knowledge of the subject since all the relevant information is delivered to the respondent by the image itself (Jensen and Koch, 1998).

The use of pictures, however, is not free from disadvantages that should be kept in mind during the analysis. Jensen and Koch (1998) underlined some important issues: first, pictures are a distillate of reality and the crucial preference determining factors (both visual and concerning other senses) might be missing; furthermore, the selection of the pictures' subjects is subjective; finally, a single disturbing factor in the picture can strongly influence its assessment.

It has been already discussed how this study and the analysis of Jensen and Skovsgaard (2009) are deeply connected, with the first being a continuation of the latter. For this reason, and in order to facilitate the result comparison, the same methodology for picture assessment was used. As described by Jensen and Skovsgaard (2009), this assessment method is an adaptation of the "experimental method", which was developed by Koch (Koch 1977a, b *in* Jensen and Skovsgaard, 2009). Respondents were asked to rank the ten photographs according to the criterion: "Which forest environment do you prefer as a visitor?" The original "experimental method" presented only seven stimuli for the interviewee, because it is thought that respondents have trouble in ranking a greater number of topics on the same occasion. Nevertheless, ten photographs were included in order to analyze all the five thinning practices from at least two points of observation.

2.6 Statistical analysis

Data merging, error tracing and the factor analysis were carried out using STATA statistical software (StataCorp., 2007), whereas the non-parametric analysis of variance was done using the statistical software R (R Development Core Team, 2011).

2.6.1 Scoring procedure and error tracing

A scoring procedure was run according to Jensen and Skovsgaard (2009): 10 points were awarded to the photograph that received the highest ranking, nine points to the next highest, and so on, down to one point for the photograph that received the lowest ranking by the respondents. Then, a preliminary analysis for error tracing in the ranking was implemented. It revealed two main types of anomalies in the data.

The first type refers to an incomplete ranking of pictures. In these cases, respondents did not rank all the pictures and some positions were left blank. The missing value was very often found in the last position; less frequently, only the first positions were filled in with pictures' numbers; in very few cases, the ranking question was left completely blank. When only one position was missing, it was completed by exclusion. For instance, if all pictures besides number 210 were included in the ranking, then 210 was filled in the white space. In this case, the intention of the respondent could be assumed with confidence. However, when the choice was ambiguous (e.g. more than one position in the ranking was missing) missing values were not modified. Scores were awarded only to the pictures in the non-missing positions of the ranking. The presence of a incomplete ranking, with eighth or less pictures ordered, could still provide useful information for the analysis. This solution was preferred to an arbitrary weighting of the excluded pictures that awarded an average score (according to the missing positions) to each of them: for example, if positions 1 and 10 were left blank, 5.5 points could have been awarded to the two pictures excluded. To the author's opinion, this averaging mechanism may generate some bias in the analysis. That is, the most and the least preferred scenes would in fact have received arbitrarily a score of 5.5, which would not have been so different to the scores of the two mid ranking scenes (position 5 and 6). Consequentially, given the low number of anomalies founded, the relatively large number of data as well as the possibility to run the analysis with unbalanced data (different number of individual scores per pictures), the missing value option appeared the most appropriate. When the ranking was not done at all, the entire observation was deleted.

The second type of anomalies refers to inconsistent rankings of pictures. In other words, the same picture was found in two positions of the ranking and therefore one picture was missing. In these cases, a missing value was substituted to the positions in the ranking where the same picture was found more than once. Again, the principle of not introducing arbitrary changes in the data was applied.

The analysis by treatments was made by averaging the scores of pictures with analogous residual stand density (Figure 5–9). Five different treatments were therefore analyzed: no thinning (7000 stems ha^{-1}), traditional thinning (5300 stems ha^{-1}), heavy thinning (1000 stems ha^{-1}), very heavy thinning (300 stems ha^{-1}), solitary trees (100 stems ha^{-1}).

2.6.2 Analysis of variances

After the scoring procedures, the mean point value for each photograph and treatment was then calculated. Afterwards, these means were compared to each other by classical parametric analysis of variance. However, this methodology is based on the assumption that the data were measured on an interval scale, whereas ranking of the 10 photographs only gives a result measured on an ordinal scale.

Therefore, a non-parametric analysis - the Kruskal-Wallis test - was also run. Similarly to the parametric analysis of variances, this test was used to investigate if there were differences in the scorings amongst type of respondents or nationalities. It was used to test the null hypothesis that all populations have identical distribution functions against the alternative hypothesis that at least two of the groups differed only with respect to location, in this case the median (Zar, 1999). Overall, results from the parametric and non-parametric analysis were analogous.

In the case in which significant differences were detected, the Nemenyi-Damico-Wolfe-Dunn *post-hoc* test was run (Hollander and Wolfe, 1999). This non-parametric *post-hoc* test performed a pair wise comparison of the mean scores.

2.6.3 Factor analysis

Factor analysis represents a group of statistical techniques concerned with the reduction of a set of observable variables in terms of a small number of latent factors. The underlying assumption of factor analysis is that there exist a number of unobserved latent variables, called factors, which are able to explain a consistent part of the total variability in the data (Harman, 1976).

In this analysis, a particular type of factor analysis called "principal component factor analysis" was used to identify possible latent variables explaining the variability of scores. The scenes in the pictures were then the original variables. This particular case of factor analysis is called "principal component factor analysis".

To summarize, it can be implemented as follow:

- a principal component analysis is run;
- the relevant factors are selected;
- a rotation of the factor axes is implemented;
- results are interpreted.

Since this methodology is not often applied in the forestry research, a brief explanation is presented in Appendix B.

3 Results

3.1 Comparison between the Danish general public and Danish experts

Recreational preferences of the Danish population were investigated in this section. The analysis were implemented focusing firstly on the ten pictures, then on the five different treatments and finally through a principal component factor analysis. The dataset regarding the Danish population was divided in two main groups: the general public - already investigated by Jensen and Skovsgaard (2009) - and the forestry and natural resources experts. The latter group was further subdivided into three categories: the forestry professionals, “green” professionals (landscape architects, environmental managers, horticulturalists, and the like) and natural resource sciences students (mostly forestry, but also landscape architecture and other natural sciences).

3.1.1 Preferences for pictures

Significant differences in visual preferences for the ten pictures were found among the four Danish population groups investigated (Kruskal-Wallis test, $\alpha = 0.05$). Results are presented in Table 5 and in Figure 11.

Although there were significant different mean score values between pictures, a clear preference for one particular picture could not be found in any of the population subgroups. Pictures 203 and 208 representing a residual stem density of 5300 and 1000 stems ha^{-1} generally received the highest mean score by all groups with the exception of the green professionals. A wider consensus emerged on the lowest positions of the ranking where, disregarding which group is considered, pictures 205 and 217 are found.

The particular positions of the pictures in the rankings were not straightforward to be interpreted. The pictures’ mean scores were analyzed with a pair wise comparisons (Nemenyi-Damico-Wolfe-Dunn test with $\alpha = 0.05$). The outcome showed that the boundaries between significant different positions were often nested and overlapping. For instance, in the general public’s preferences, picture 203 is in the first place, but is mean score was not significantly different from the mean scores of pictures 208 and 210. As a consequence, it is not possible to reject the hypothesis that the three forest scenes are equally preferred and all of them should be considered as the most preferred forest environment for recreation in young oak stand. However, this would be only partially correct, since picture 210 has a mean score value that is not significantly different from the ones of pictures 201, 215 and 207.

Nevertheless, it was still possible to extract some general tendencies about the forest recreational preferences of the four groups of respondents. As far as the general public is concerned, pictures 203, 208 and 210 representing rather high to low stem densities (5300–300 stems ha^{-1}) seemed to be preferred over pictures showing very dense (7000 stems ha^{-1}) or extremely open stands (100 stems ha^{-1}). In Figure 11, the pictures were ordered in the horizontal axis from the highest to the lowest residual stem density; therefore, a different residual stem density was presented each two pictures, with the first photograph of the pair depicting a row-wise structure. It can be noticed that, in most of the cases, a row-wise structure got a higher mean score. The difference in scores between the two pictures within the same stand density was lower in more open stands where the row effect fades.

With reference to forestry professionals, they favoured firstly pictures 208, then picture 203 and thirdly picture 220, although there were not significant differences between the three mean score values. In addition, in this case, very dense stands (picture 215 and 205) and very open stands (picture 207 and 217) were in the lowest part of the ranking. Turning to the students' preferences, stands with a medium to high residual stand density (picture 203, 211, 208) were singled out. Their preferences tended to increase sharply by moving from very high (7000 stems ha^{-1}) to high stand densities (5300 stems ha^{-1}), and then monotonically decreasing with more open stands. For both forestry professionals and students there appeared to be a score premium for row structures within the same treatment, again with the exception of the pair of picture 211 and 203. In most cases, the general public, forestry professionals and students exhibited a similar preference trends.

In contrast, green professionals presented quite a unique preference shape. The differences between the ranking positions were not easy to be analyzed since the data did not present a clear relationship between residual stand density and recreational preferences. However, from a heuristic graphic analysis it was possible to affirm that there was a substantial indifference between high to medium stand densities (5300–1000 stems ha^{-1}) and low stand densities (100–300 stems ha^{-1}), with a mild predilection for the latter. Moreover, very dense stands had a negative impact on green professionals' recreational preferences.

Table 6 shows the results of assessments of pictures between the four different segments of respondents. Statistical significant differences in visual preferences were found for five pictures (Kruskal-Wallis test, $\alpha = 0.05$): 211,

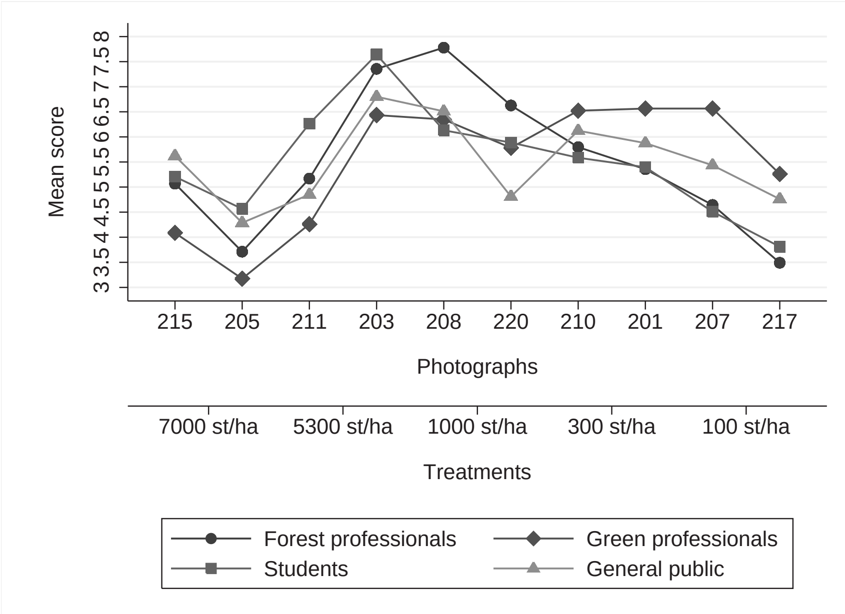


Figure 11: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of experts and the general public (highest score=10, lowest score=1).

Table 5: Ranking of pictures representing precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between experts' and general public's preferences.

	Forestry professionals		Green professionals		Students		General public	
#	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*
1	208	A	201	A	203	A	203	A
2	203	AB	207	A	211	AB	208	A
3	220	ABC	210	A	208	ABC	210	AB
4	210	BCD	203	A	220	BC	201	B
5	201	CDE	208	A	210	BC	215	BC
6	211	CDE	220	A	201	BCD	207	BC
7	215	DCEF	217	AB	215	BCD	211	CD
8	207	DEF	211	AB	205	BCD	220	CD
9	205	EF	215	AB	207	CD	217	CD
10	217	F	205	B	217	D	205	D

* Positions with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 6: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between experts' and general population's preferences (highest score=10, lowest score=1).

Population's segment	n	No thinning (7000 stems/ha)		Traditional th. (5300 stems/ha)		Heavy thinning (1000 stems/ha)		Very heavy th. (300 stems/ha)		Solitary trees (100 stems/ha)	
		215	205	211	203	208	220	210	201	207	217
Foresters	59	5.07^{A}	3.71^{A}	5.17^{AB}	7.36^{A}	7.78^{A}	6.63^{A}	5.80^{A}	5.36^{A}	4.64^{B}	3.49^{B}
Green professionals	23	4.08^{A}	3.17^{A}	4.26^{B}	6.43^{A}	6.35^{B}	5.78^{AB}	6.52^{A}	6.57^{A}	6.57^{A}	5.26^{A}
Students	53	5.21^{A}	4.57^{A}	6.26^{A}	7.64^{A}	6.13^{B}	5.89^{A}	5.58^{A}	5.40^{A}	4.51^{B}	3.81^{B}
General public	242	5.62^{A}	4.29^{A}	4.85^{AB}	6.80^{A}	6.51^{B}	4.81^{B}	6.12^{A}	5.88^{A}	5.43^{AB}	4.76^{A}
K-W p-value		0.103	0.209	0.004*	0.097	0.0008*	0.000*	0.304	0.259	0.009*	0.004*

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

208, 220, 207 and 217. In general, students likely favoured denser stands more than green professionals did. Foresters had a tendency to score higher managed stands with 1000 stem ha^{-1} (picture 208 and 220) compared to the general public and green professionals. The latter scored higher the open woodlands (picture 217 and 207) than the other three groups.

The scores given by the Danish general public and the Danish expert groups to the pictures representing very dense stands (pictures 215 and 205, 7000 stems ha^{-1}) and open stands (pictures 210 and 201, 300 stems ha^{-1}) were similar. Furthermore, all segments assigned similar scores for picture 203, the most preferred by the general public and students.

3.1.2 Preferences for treatments

Significant differences among recreational preferences in young oak stand treatments were found within the four segments investigated (Kruskal-Wallis, $\alpha = 0.05$). Results are presented in Table 7 and in Figure 12.

Correspondingly to the picture analysis, the general public exhibited preferences for a stands with low to high stem numbers (from 300 to 5300 stems ha^{-1}) considering them the most suitable for forest recreation. Very heavy thinning received a higher score than traditional thinning and heavy thinning; however, the difference is not significant. The first two treatments were clearly preferred over no thinning and extremely high thinning. Students showed a preference for the traditional thinning practice which was favoured over very heavy thinning, solitary trees as well as over no thinning. The difference between heavy thinning and the traditional thinning was not significant. Similar to the previous two groups, forestry professionals assigned low values to the no thinning and the solitary trees options. As for the picture analysis, they still preferred the heavy thinning practice. Green professionals were rather indifferent between treatments resulting in low to very low stem density and they penalized dense stands.

Turning to the comparison of the group preferences presented in Table 8, significant different scores were found for all the treatments with exception of the very heavy thinning (Kruskal-Wallis test,$\alpha = 0.05$). No thinning was disliked by green professionals who assigned to it a significant lower average score compared to the other groups. Students showed a significantly higher preference for the traditional thinning compared to the general public and the green professionals. Preferences related to the heavy thinning showed a three-level structure, with foresters showing the highest appreciation, students and green professionals in the middle and the general public

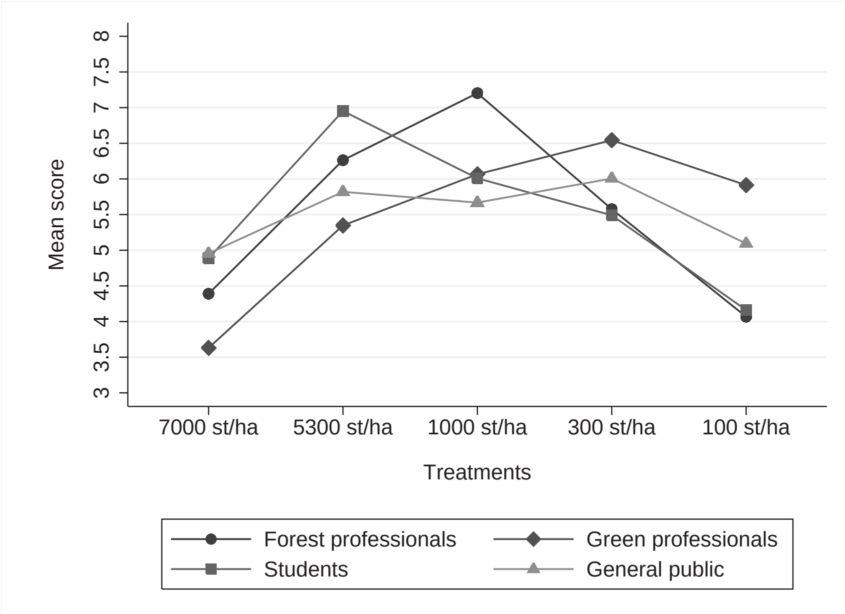


Figure 12: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between experts' and general population's preferences (highest score=10, lowest score=1).

Table 7: Ranking of five different precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between experts' and general public's preferences.

	Forestry professionals		Green professionals		Students		General public	
#	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*
1	1000	A	300	A	5300	A	300	A
2	5300	AB	1000	A	1000	AB	5300	A
3	300	BC	100	A	300	BC	1000	AB
4	7000	CD	5300	AB	7000	BC	100	B
5	100	D	7000	B	100	C	7000	B

* Positions with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 8: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between experts' and general population's preferences (highest score=10, lowest score=1).

Population segment	n	No thinning (7000 st/ha)	Traditional thinning (5300 st/ha)	Heavy thinning (1000 st/ha)	Very heavy thinning (300 st/ha)	Solitary trees (100 st/ha)
Forestry prof.	59	4.39^{A}	6.26^{AB}	7.20^{A}	5.58^{A}	4.07^{B}
Green prof.	23	3.63^{B}	5.35^{B}	6.07^{B}	6.54^{A}	5.91^{A}
Students	53	4.89^{A}	6.95^{A}	6.01^{B}	5.49^{A}	4.16^{B}
General public	242	4.95^{A}	5.82^{B}	5.67^{C}	6.01^{A}	5.09^{A}
K-W p-value		0.048*	0.004*	0.000*	0.086	0.001*

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

conferring the lowest average score. The solitary trees option was ranked significantly higher by the general public and green professionals (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

In summary, different thinning intensities were selected as the most preferred one by the three groups of expert. Students showed a preference for the traditional thinning, foresters for the heavy thinning and green professionals for the very heavy thinning. In contrast, the general public preference structure changed towards a wider and more undefined set of treatments with analogous scores (300, 1000 and 5300 stems ha^{-1}).

3.1.3 Preferences for photo factors

A principal component factor analysis was run to investigate whether respondents perceived treatments as different from each other and accordingly scored pictures or, in contrast, they perceptually grouped pictures conforming to other undergoing factors influencing recreational preferences. The analysis was run separately for the general public and the experts (forestry professionals, green professionals and students). The reason behind this subdivision was that forestry or natural resources management education could influence the perception of differences among pictures and treatments.

Three techniques were applied to select the number of relevant factors (scree plot analysis, Kaiser's rule and parallel analysis). They all leaded to the retention of three factors in the general public dataset. These three factors all together could explain about 67% of the total variance in the data. With reference to the experts' dataset, only the Kaiser's rule and scree plot analysis indicated the presence of three factors. The parallel analysis tended to favour a two-factor structure, but the third factor was on the borderline between inclusion and exclusion. As a consequence, a three factor structure was preferred for the experts' dataset. Overall, the tree factors accounted for 69% of the total variation of the experts' scores.

Table 22 in Appendix C presents the correlation coefficients (or factor loadings) between factors and pictures' scores by the general public, resulting from the principal component analysis. Once the relevant factors had been selected a varimax rotation was run to facilitate interpretation of the relevant factors. The correlation coefficients between the rotated factors and the pictures' scores are showed in the right part of the table. Table 23 in Appendix C presents the correspondent results from the Danish experts' data.

In order to facilitate the understanding of these factors and trying to isolate some patterns between and within the results of the principal component factor analysis, pictures were grouped together according to their larger correlation coefficient with one of the three rotated factors, defining a sort of scene types. In other words, each picture was assigned to the factor with which the rotated loading was positive and larger than the other rotated factor loadings. For instance, in the professionals and student case, picture 215 has a rotated factor loading of 0.57 relative to factor 1, 0.23 relative to factor 2 and −0.51 relative to factor 3 (Table 23). As a consequence, it has to be assigned to factor 1, with which it has the larger positive correlation.

Tables 9 and 10 show the results respectively for the general public and the experts. In the tables, four main characteristics of each photograph are also listed: the residual stem density, the presence or absence of slash, the presence or absence of a distinguishable row structure and the visibility of the sky in the background. On the last column of each table, the average score for each scene type is computed by averaging the scores of the pictures included in that group. Significant differences among mean score values were investigated (Nemenyi-Damico-Wolfe-Dunn post hoc-test, $\alpha = 0.05$).

As far as the general population is concerned, pictures 201, 207, 217 and 210 were ascribed to factor 1 or scene type 1. These four pictures presented similar low or very low densities. Slash was present in most of the pictures with exception of picture 210 that had luxuriant ground vegetation. A distinguishable row structure was absent and a blue sky in the background was strongly characterizing only half of pictures in the group. For these characteristics and for a overall visual impression this factor was labelled

Table 9: Preferences on scene types in even aged stands of penduculate oak in Denmark resulting from the principal component factor analysis of the general public data.

Factor no.	Scene type	Picture	Picture characteristics: stems ha^{-1}	slash presence	row structure	sky visibility	Scene mean score*
1	Open woodland	207	100	Yes	No	Yes	5.55^B
		217	100	Yes	No	No	
		210	300	No	No	No	
		201	300	Yes	No	Yes	
2	Forest with row structure	208	1000	Yes	Yes	No	6.06^A
		215	7000	No	Yes	No	
3	Forest with low accessibility	220	1000	Yes	No	No	4.81^C

* Scores with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 10: Preferences on scene types in even aged stands of penduculate oak in Denmark resulting from the principal component factor analysis of forestry and green professionals and students data.

Factor no.	Scene type	Picture	Picture characteristics: stems ha^{-1}	slash presence	row structure	sky visibility	Scene mean score*
1	High density forest	215	7000	No	Yes	No	5.42^B
		205	7000	No	No	No	
		211	5300	No	No	No	
		203	5300	No	No	No	
2	Mid density forest	208	1000	Yes	Yes	No	6.54^A
		220	1000	Yes	No	No	
3	Open woodland	217	100	Yes	No	No	5.11^B
		210	300	No	No	No	
		201	300	Yes	No	Yes	

* Scores with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

as “open woodland”. The second factor was composed by picture 208 and 215. These two photographs showed a clear and distinct row structure. The residual stem density varied from the 1000 stems ha^{-1} of picture 208 to the 7000 stems ha^{-1} of picture 215. Due to the medium high density, the sky is not characterizing the background, although it could be perceived in picture 208. Slash could be observed in picture 208, but in the middle of the picture there was a free-from-slash row. Among the four characteristics, the raw structure was the one joining these two pictures. Therefore, this scene type was labelled “forest with a row structure”. The third factor coincided with picture 220, which shows a medium density stand, without any raw structure and a significant amount of slash in the ground. This last scene type was called “forest with low accessibility”.

The general public preferences selected the “forest with a row structure” as the most preferred scene type. The second best scene was the “open woodland” and “forest with low accessibility” appeared to be the least preferred. The mean score values were found significantly different.

Turning the analysis to professionals and students, the first factor grouped together all the pictures (215, 205, 211, 203) representing the very high and high densities. Slash residuals were not present and ground vegetation was present with different intensities. A distinct row structure was present in one picture but could not be addressed as a characteristic of this group. Pictures 208 and 220 defined the second factor or scene type. These two pictures showed exactly the same treatment type with a residual stem density of 1000 stems ha^{-1}. Slash was found in both pictures. However, differently from picture 220, picture 208 presented a row structure and strip free from residuals. Factor 3 included pictures 217, 210 and 201. As for the former two factors, the range of residuals stem density was similar among the components. Moreover, the three photographs shared the absence of row structure. In contrast, they showed different patterns regarding slash presence and the presence of the sky in the background. Given that there was a sound homogeneity within the three factors regarding the range of residual stem density, this first factor was labelled as “high density forest”, the second one as “mid density forest” and the third factor “open woodland”.

“Mid density forest” resulted as the most preferred scene type by the professionals and students. This scene received a significantly higher average score than the “high density forest” and the “open woodland” scene types. Although the “high density forest” had a higher average score than the “open woodland”, the difference is not significant (Nemenyi-Damico-Wolfe-Dunn post hoc-test, $\alpha = 0.05$).

3.2 Comparison between forestry professionals across Europe

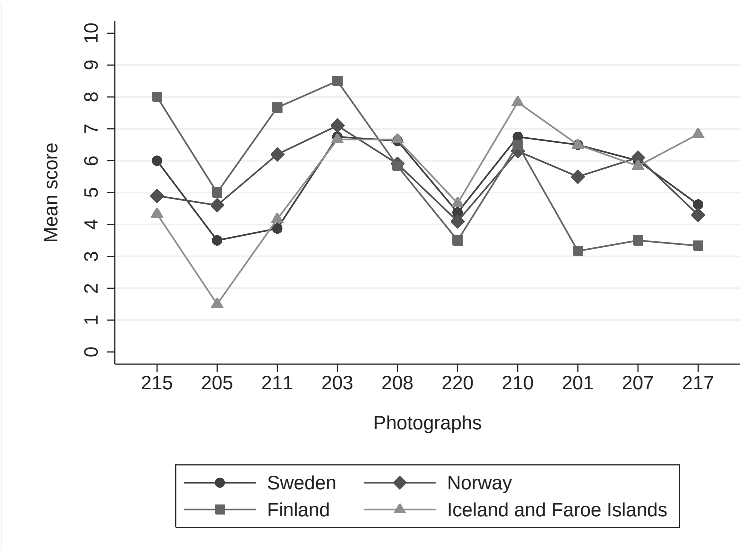
The results from the analysis of the recreational preferences of forestry professionals are presented in this section. As for the Danish population study, the analysis is structured firstly by pictures, then on treatments and finally by photo factors through a principal component factor analysis.

Given the low number of forestry professionals interviewed per country and the consequential scattered geographical distribution of respondents, the analysis was run by groups of countries. Each forest professionals were assigned to one of the following country groups: Denmark, other Nordic countries, non-continental Europe, Central Europe and Southern Europe. Denmark was kept separate as a benchmark with other studies. Groups and the relative countries were presented in Table 3 at p. 33.

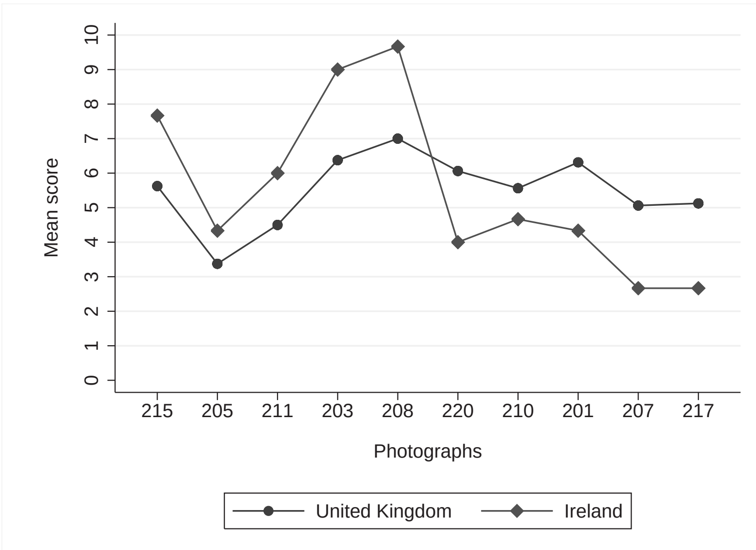
The definition of grouping is not an easy task and some assumptions are requires. In this case, the undergoing hypothesis was that within a geographical region there is a certain level of uniformity regarding preferences. In particular, individuals are supposed to be used to the same landscape type, to receive similar education and cultural influences. For example, according to this assumption, a Finnish forester's judgment of a forest environment is based on his/her environmental, socio-cultural and professional background. This background is supposed to be closer to the background of a forester coming from another Scandinavian country rather than the background of a Spanish or Portuguese forestry professional.

Figure 13 presents a comparison of the picture assessment among countries within the same geographical region. To simplify the graphic analysis nations with less than three respondents were put together. In sub-figure 13a, the picture assessment of the other Nordic countries group is decomposed by country. Overall, the pattern appeared to be similar among nations, in particular for picture 203, 208, 220 and 210. Regarding the other pictures, the larger difference was found between Finland and Sweden. The former tended to favour denser stand and less open and very open stands, whereas for the latter the opposite is true. Other countries' assessments were mostly between the Finnish and Swedish positions.

In sub-figure 13b, it is possible to observe the non-continental Europe group composed by UK and Ireland. Compare to the British, Irish respondents ranked higher dense stands and lower open stands. Picture 208 and 203 appeared to be the most preferred ones, and similar preference patterns were found among the very dense and very open pictures. The Irish line, however, is much more volatile. This is because in the data there are only three

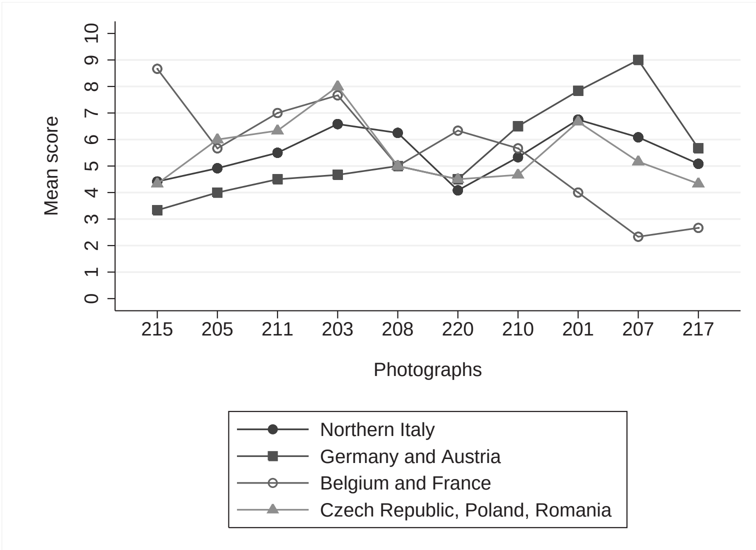


(a) Other Nordic countries.

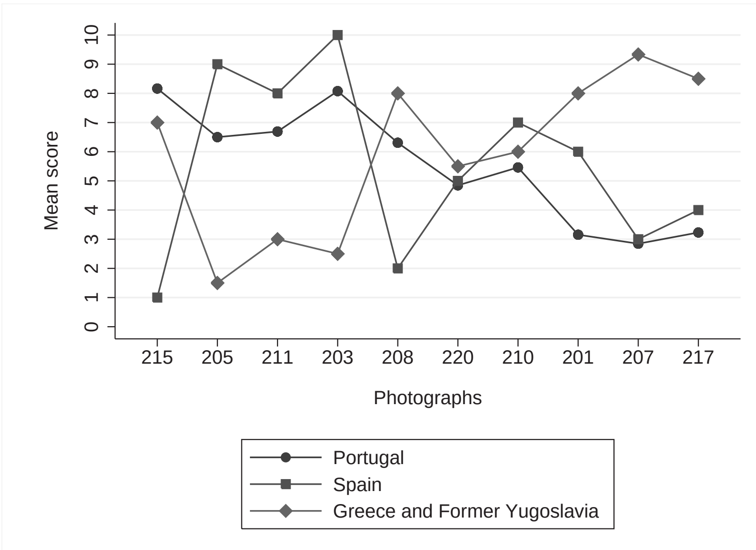


(b) Non-continental Europe.

Figure 13: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of forestry professionals by country within country groups (highest score=10, lowest score=1). [*Continue on next page*].



(c) Central Europe.



(d) Southern Europe.

Figure 13: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of forestry professionals by country within country groups (highest score=10, lowest score=1). [*Follow from previous page*].

Irish respondents. Actually, by increasing the number of respondent, the mean score for each picture is likely to move towards central values of the 1-10 scale because of the averaging process. For example, consider three respondents ranking a certain picture. Two of them ranked it as the best forest environment, whereas the last one put it in the second place. The average score of that picture would be 9.33. Afterwards, a new questionnaire was collected. The new respondent ranked the picture in the eighth position, meaning that only 3 points had to be assigned to the picture. This shifted the average consistently down, to 7.75. Of course, this does not mean that it is not possible to observe very high average score values. The example is just a warning in interpreting results derived only on few observations.

Sub-figure 13c shows the picture preference for the Central European countries. Two contrasting patterns could be identified: on one hand, the French and Belgian foresters preferred very dense and dense stands to very open stands, whereas German and Austrian favoured low densities over high densities. Italian foresters' preferences lied on an intermediate position between the former two subgroups. Eastern European foresters showed preferences similar to Italian forestry professionals concerning open and very open stands as well as for picture 220 and 215, and to French and Belgian foresters regarding picture 205, 211, 203 as well as 208.

The Southern European group is presented in sub-figure 13d. The average preferences of this group are strongly influenced by Portuguese respondents representing three quarters of the Southern European foresters interviewed. The only Spanish respondent seemed to have an analogous preference pattern than the Portuguese (except for picture 215 and 208). On the contrary, forestry professionals from the South-eastern part of Europe presented a different preferences. They promoted open stands over dense stands. As a consequence, they tended to smooth Portuguese preferences by increasing the average scores picture representing very and extremely heavy thinnings and lowering the scores of pictures depicting denser stands.

As already discussed in Chapter 2, the most critical assumption in the grouping process was to which group Italian respondents should be assigned, given that they all came from the Northern part of the country. Based on landscape type and silvicultural tradition, it was chosen to group them together with Central European countries. Figure 14 compares Italian forestry professionals' preferences with Southern and Central European foresters'. From a graphical analysis, this assumption seemed to be reasonable, since the preference patterns of Italy and Central Europe appeared to be very similar. Hence, including Italian respondents tended to magnify the differ-

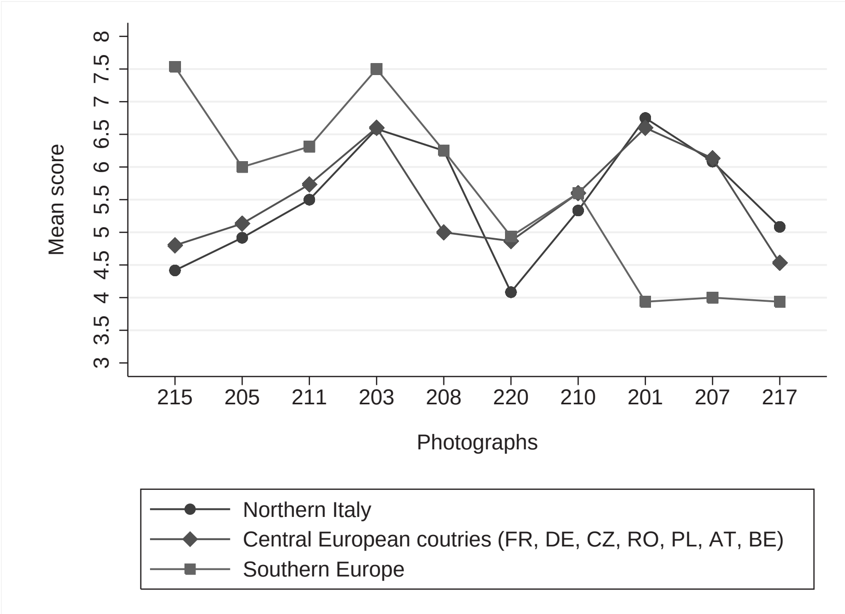


Figure 14: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between Italian, Central European and Southern European forestry professionals

ence between the assessment of medium density pictures by increasing the average score of picture 208 and decreasing the one of picture 220.

3.2.1 Preferences for pictures

Results from the pictures' ranking and preference patterns are presented in Table 11 and in Figure 15, respectively. Significant differences in visual preferences for the ten pictures were found among all groups with the exception of Central Europe (Kruskal-Wallis test, $\alpha = 0.05$). Central European foresters' ranking did not presented significant differences between positions. In other words, the average score of picture 201, in the first position, is not significantly different from the average score of picture 220, found in the last position (Nemenyi-Damico-Wolfe-Dunn test with $\alpha = 0.05$). Moreover, a common preference for one particular picture could not be found among European forestry professionals. Given that in some groups differences among positions were seldom significant (Nemenyi-Damico-Wolfe-Dunn test with $\alpha = 0.05$), the particular positions of the pictures in the rankings were not straightforward to be interpreted.

Table 11: Ranking of pictures representing precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between forestry professionals across Europe.

	Denmark		Central Europe		Non-continental Europe		Other Nordic countries		Southern Europe	
#	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*
1	208	A	201	A	208	A	203	A	215	A
2	203	AB	203	A	203	A	210	AB	203	A
3	220	ABC	207	A	201	AB	208	ABC	211	AB
4	210	BCD	211	A	215	AB	215	ABCD	208	AB
5	201	CDE	208	A	220	AB	201	ABCD	205	AB
6	211	CDE	210	A	210	AB	207	ABCD	210	AB
7	215	DCEF	205	A	211	AB	211	ABCD	220	AB
8	207	DEF	217	A	217	AB	217	BCD	207	B
9	205	EF	215	A	207	AB	220	CD	201	B
10	217	F	220	A	205	B	205	D	217	B

* Positions in the ranks with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 12: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between forestry professionals across Europe.

Country group	n	No thinning (7000 stems/ha)		Traditional th. (5300 stems/ha)		Heavy thinning (1000 stems/ha)		Very heavy th. (300 stems/ha)		Solitary trees (100 stems/ha)	
		215	205	211	203	208	220	210	201	207	217
Denmark	59	5.07^{AB}	3.71^{B}	5.17^{A}	7.36^{A}	7.78^{A}	6.63^{A}	5.80^{A}	5.36^{AB}	4.64^{A}	3.49^{A}
Central Europe	27	4.63^{B}	5.04^{AB}	5.63^{A}	6.59^{A}	5.56^{B}	4.52^{B}	5.48^{A}	6.67^{A}	6.11^{A}	4.78^{A}
Non-con. Europe	19	5.95^{AB}	3.53^{B}	4.74^{A}	6.79^{A}	7.42^{AB}	5.74^{B}	5.42^{A}	6.00^{AB}	4.68^{A}	4.74^{A}
Nordic countries	30	5.70^{AB}	3.77^{B}	5.47^{A}	7.20^{A}	6.23^{B}	4.17^{B}	6.77^{A}	5.50^{AB}	5.50^{A}	4.70^{A}
Southern Europe	17	7.53^{A}	6.00^{A}	6.13^{A}	7.50^{A}	6.25^{B}	4.94^{B}	5.60^{A}	3.94^{B}	4.00^{A}	3.94^{A}
K-W p-value		0.012*	0.034*	0.485	0.608	0.000*	0.000*	0.251	0.032*	0.103	0.114

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

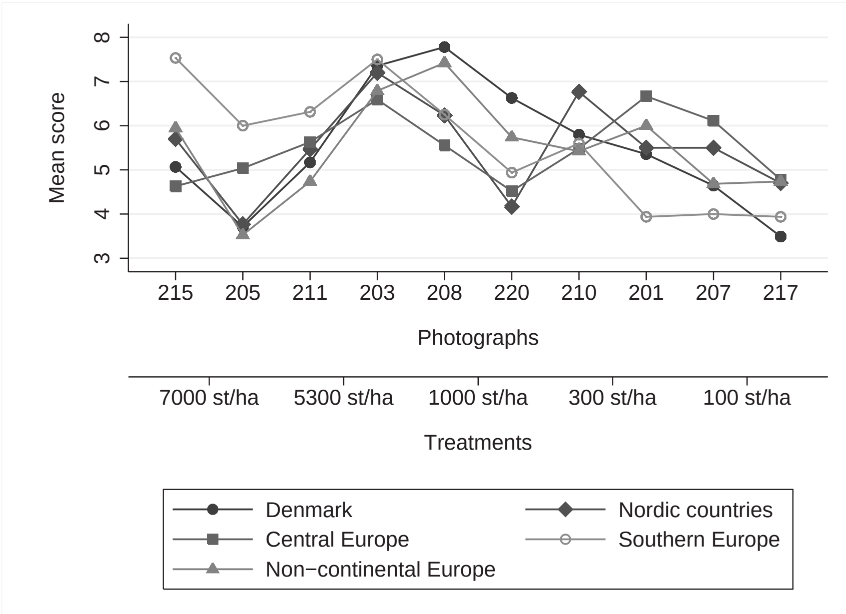


Figure 15: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of forestry professionals across Europe (highest score=10, lowest score=1).

Denmark, other Nordic countries and non-continental Europe presented similar features in the ranking. In particular, Denmark selected pictures 208, 203 and 220 representing a residual stem density of 1000 and 5300 stems ha^{-1}, as the best forest environment. Similarly, non-continental Europe singled out picture 208 and 203 to be the most preferred ones. Picture 203 was put in the first place by foresters from the Nordic countries and picture 208 in the third one. As far as the lowest positions of the ranking are concerned, Danish forester and Nordic forester identified respectively a set of four and three photographs: pictures 215, 205, 207, 217 (depicting very dense or extremely open stands) were selected by the Danes; similarly picture 205 and 207, with the addition of picture 220, were singled out by Nordic forestry professionals. With regard to non-continental Europe, only picture 205 (depicting a very dense stand) showed a mean score value significantly lower than other photographs, although pictures 207 and 217 (showing extremely open stands) were found in the bottom positions of the ranking.

Southern European foresters preferred pictures illustrating very dense and dense stands to photographs reproducing open or very open stands. In particular, pictures 215 and 203 received a significantly higher mean score than pictures 207, 201 and 217.

From a graphical analysis of Figure 15, a score premium for the presence of a row structure was found only for the Danish, the Nordic and the Southern European groups. It must be underlined that this does not hold for photographs related to a stem density of 1000 stems ha^{-1}. Interestingly, in the Central European group, the score premium was absent especially in the very dense and dense stand pictures.

Table 12 shows the results of assessments of pictures between the five different segments of respondents. Statistical significant differences in visual preferences were found for five pictures (Kruskal-Wallis test, $\alpha = 0.05$): 215, 205, 208, 220, 201. Compared to other country groups, Southern European foresters tended to score higher pictures depicting very dense stand (picture 215 and 205) and lower the picture representing an open stand (picture 201). In contrast, Danish foresters had a tendency to score higher managed stands with 1000 stems ha^{-1} compared to other country groups (with exception of non-continental Europe in relation of picture 208).

The scores given by European foresters to the pictures representing dense stand (pictures 211 and 203, 5300 stems ha^{-1}) and extremely open stands (pictures 207 and 217, 100 stems ha^{-1}) were similar. Furthermore, all respondents' segments had similar scores for picture 210 showing a open stand with 300 stems ha^{-1}.

Results presented in Table 12 are confirmed by the graphical preference patterns in Figure 15. The Southern Europe line is over other groups' lines for very dense and dense stands, whereas it tends to be below them for open stands. In the denser part of the treatments' spectrum, the preference pattern of Danish foresters is very similar to the ones relative to other Nordic countries and non-continental Europe. Then, for mid densities, Central Europe group moves closer to non-continental Europe, while Danish foresters' preference pattern diverges. Moreover, non-continental and Central Europe as well as Nordic countries have similar preference pattern also for open and very open stands.

3.2.2 Preferences for treatments

Results from the assessment of treatments in young oak stands are presented in Table 13 and in Figure 16. Significant differences among recreational preferences were found within only three country groups (Kruskal-Wallis, $\alpha = 0.05$): Denmark, other Nordic countries and Southern Europe. As for the picture analysis, Central Europe did not showed any significant

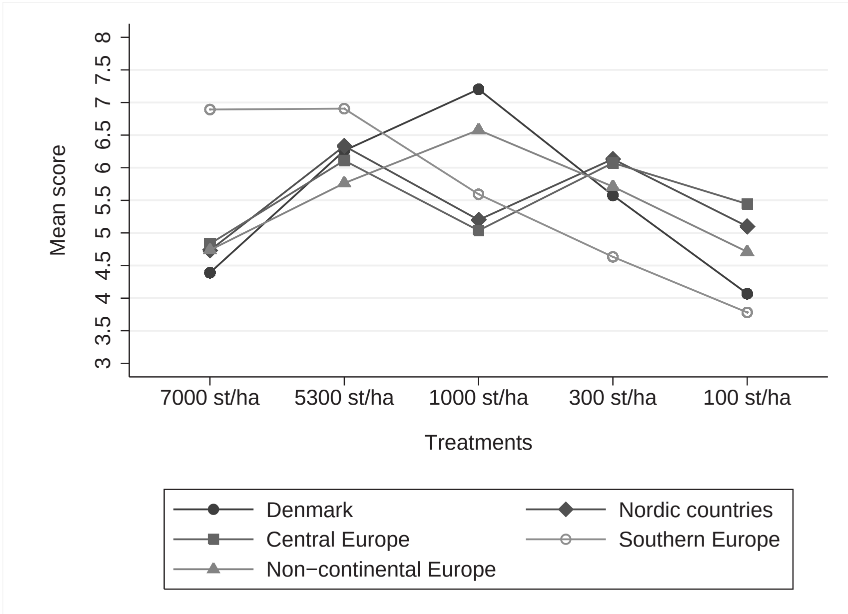


Figure 16: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of forestry professionals across Europe. (highest score=10, lowest score=1).

difference between different positions of the treatment ranking. For the non-continental Europe, however, differences were found at the 10% significance level, with heavy thinning significantly preferred over no thinning (7000 stems ha^{-1}) and solitary trees (100 stems ha^{-1}).

Denmark as well as non-continental Europe ranked treatments in the same order, although the difference between positions could not always be considered significant (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). They selected the heavy thinning, followed by the traditional thinning, as the most suitable treatments for improving the recreational quality of the stand and the solitary trees and no thinning as the least advisable. Likewise, foresters from Central Europe and the Nordic countries exhibited the same treatment ranking. They reserved the first position to the traditional thinning and the last one to the no thinning option. Consistently, analogous patterns of preferences between Denmark and non-continental Europe and between Central Europe and Nordic countries appeared from Figure 16.

A different type of preferences are observed for Southern European forestry professionals, who singled out the traditional thinning and the no thinning

Table 13: Ranking of five different precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between forestry professionals across Europe.

	Denmark		Central Europe		Non-continental Europe		Other Nordic countries		Southern Europe	
#	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*
1	1000	A	5300	A	1000	A	5300	A	5300	A
2	5300	AB	300	A	5300	A	300	AB	7000	AB
3	300	BC	100	A	300	A	1000	AB	1000	ABC
4	7000	CD	1000	A	7000	A	100	AB	300	BC
5	100	D	7000	A	100	A	7000	B	100	C

* Positions in the ranks with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 14: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between forestry professionals across Europe (highest score=10, lowest score=1).

Country group	n	No thinning (7000 st/ha)	Traditional thinning (5300 st/ha)	Heavy thinning (1000 st/ha)	Very heavy thinning (300 st/ha)	Solitary trees (100 st/ha)
Denmark	59	4.39^{B}	6.11^{A}	7.20^{A}	6.07^{A}	4.07^{A}
Central Europe	27	4.83^{AB}	6.84^{A}	5.04^{C}	5.29^{A}	5.44^{A}
Non-continental Europe	19	4.74^{AB}	5.76^{A}	6.58^{B}	5.71^{A}	4.71^{A}
Other Nordic countries	30	4.73^{AB}	6.33^{A}	5.20^{C}	6.13^{A}	5.10^{A}
Southern Europe	17	6.89^{A}	6.91^{A}	5.59^{BC}	4.63^{A}	3.78^{A}
K-W p-value		0.015*	0.684	0.000*	0.172	0.083

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

as the most preferred practices with similar average scores. It is interesting to notice that, from the medium to the very low range of stem densities, the treatments' mean scores decreased monotonically with higher thinning intensities. This pattern is distinctly represented in Figure 16.

Table 14 presents the comparison of the assessment of each treatment type made by the five country groups. Significant differences were found for the no thinning and the heavy thinning options. The average score for the no thinning option ranged between the 6.89 of Southern Europe to the 4.39 if Denmark. These two values were significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$), whereas all other pair wise comparisons were not. Turning to the heavy thinning, it is possible categorized average scores in three significantly different levels of appreciation (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). Danish forestry professionals are found in the first place. They assigned to this treatment the highest average score, which is significantly different from the average scores recorded for other country groups. In the second place, there are the foresters from the non-continental Europe. In the third place, the Central European and the Nordic forestry professionals attributed to the heavy thinning the lowest average scores. Southern European's mean score could be collocated in between the non-continental Europe and the Nordic countries.

3.2.3 Preferences for photo factors

As for the Danish population, a principal component factor analysis was run to investigate how European foresters perceived the different treatments and scored the pictures. In other words, the principal component factor analysis was implemented to search for potential undergoing factors influencing recreational preferences.

Three techniques were applied to select the number of relevant factors. The scree plot and the Kaiser's rule indicated the presence of three relevant factors. The parallel analysis suggested a two-factor structure, but the third factor was on the borderline between inclusion and exclusion. Three relevant factors were then selected, representing approximately 70% of the total variation in the data.

Table 24 in Appendix C presents the factors and the respective factor loadings resulting from the principal component analysis. Once the relevant factors had been selected a varimax rotation was run to facilitate the interpretation. The rotated factor loadings are showed in the right part of the table.

Table 15: Preferences on scene types in even aged stands of penduculate oak in Denmark resulting from the principal component factor analysis of European forestry professionals.

Factor no.	Scene type	Picture	Picture characteristics: stems ha^{-1}	slash presence	row structure	sky visibility	Scene mean score*
1	High density forest	215	7000	No	Yes	No	5.55^{B}
		205	7000	No	No	No	
		211	5300	No	No	No	
		203	5300	No	No	No	
2	Mid density forest	208	1000	Yes	Yes	No	6.17^{A}
		220	1000	Yes	No	No	
3	Open woodland	217	100	Yes	No	No	5.18^{B}
		210	300	No	No	No	
		201	300	Yes	No	Yes	

* Scores with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

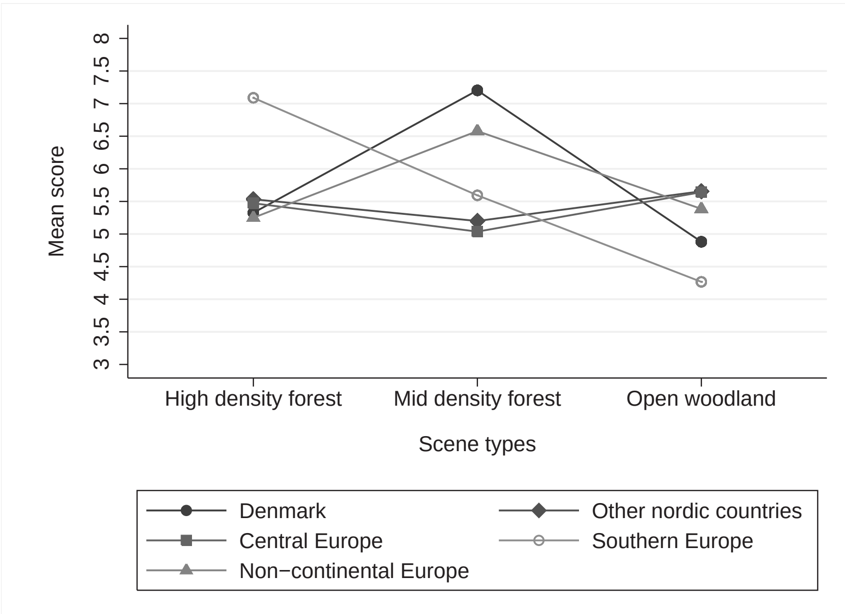


Figure 17: Preferences on scene types in even aged stands of penduculate oak in Denmark derived from the principal component factor analysis of the European forestry professionals' data, average scores by country.

After the varimax rotation, pictures were grouped together according to their larger positive correlation coefficient (or factor loading) with one of the three rotated factors. Then, their common characteristics were analyzed in order to identify the scene types. Results are presented in Table 15. In the table, the main characteristics of each photograph are listed: the residual stem density, the presence or absence of slash, the presence or absence of a distinguishable row structure and the visibility of the sky in the background. On the last column, the average score for each scene type is presented.

As it can be noticed in Table 15, results of the principal component factor analysis among European foresters are similar to the results obtained for the Danish experts. The first factor grouped together the picture illustrating dense and very dense stands (picture 215, 205, 211, 203). The second factor was defined by two pictures (208 and 220) sharing the same stand density of 1000 stems ha^{-1}. Factor 3 was related to pictures 217, 210 and 201 characterized by low and very low residual stem densities (300–100 stems ha^{-1}). For the same reasons discussed for the Danish experts' factor analysis, the first factor was labelled as "high density forest", the second one as "mid density forest" and the third factor "open woodland".

Overall, the scene type "mid density forest" resulted as the most preferred by European foresters considered as a whole (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). However, when scene types were evaluated separately for each country group different results emerged. Figure 17 illustrates that "mid density forest" was preferred only by foresters from Denmark and from the non-continental Europe. Southern European foresters favoured the "high density forest" scene type, whereas Nordic and Central European forestry professionals were rather indifferent between the three scene types with a feeble preference for "open woodland".

3.3 Comparison between natural resources students across Europe

Results from the analysis of the recreational preferences of natural resources (mostly forestry) students are presented in this section. As for the previous investigations, results are presented firstly for the picture analysis, then for the analysis by treatments and finally for the principal component analysis. Natural resources students were grouped by their countries of origin: Austria, Denmark, United Kingdom, Portugal, Romania and Sweden.

3.3.1 Preferences for pictures

Significant differences in recreational preferences for the ten pictures were found among European natural resources students (Kruskal-Wallis test, $\alpha = 0.05$). Results are presented in Table 16 and in Figure 18.

Form the rankings in Table 16, it emerged that none of the groups expressed a clear preference for a single picture. Although picture 203 (5300 stems ha^{-1}) could be found in the first place of all rankings with the exception of Sweden, its mean score value was not statistically different from the ones of other pictures in the following three to six positions, depending of which country is examined (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). Similar considerations could be made concerning the last positions of the rankings. On average, students from Denmark, Austria and Romania singled out picture 217 (100 stems ha^{-1}) as the least preferred forest environment, the Portuguese selected picture 207 (100 stems ha^{-1}), the British pictures 201 (300 stems ha^{-1}), whereas the Swedes apparently disliked picture 205 (7000 stems ha^{-1}). However, according to the results of the Nemenyi-Damico-Wolfe-Dunn test ($\alpha = 0.05$), the last position could not be assigned uniquely because the mean score of the last picture was not statistically different from the mean score of the photographs in the positions immediately above.

Consequently, results from picture rankings are not straightforward to be interpreted. As for the Danish population and the European forester analyses, the boundaries between significant different positions were overlapping. Nonetheless, some general indications could be isolated from the picture rankings.

Austrian students seemed to favour pictures with very high and high stem densities (5300–7000 stems ha^{-1}) over pictures showing low and very low stem densities (300–100 stems ha^{-1}). The former (pictures 211, 203, 215,

Table 16: Ranking of pictures representing precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between natural resources students from different European countries.

	Denmark		Austria		Portugal		Romania		Sweden		UK	
#	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*	Photo	NDWD test*
1	203	A	203	A	203	A	203	A	210	A	203	A
2	211	AB	208	AB	215	A	215	AB	208	AB	208	AB
3	208	ABC	211	ABC	211	AB	208	ABC	203	ABC	220	AB
4	220	BC	205	ABC	205	AB	210	BC	201	ABC	210	AB
5	210	BC	215	BC	210	ABC	211	BC	207	ABC	211	AB
6	201	BCD	207	BC	208	ABC	205	CD	215	ABC	215	B
7	215	BCD	210	BC	220	BC	207	CD	211	BCD	217	B
8	205	BCD	201	BC	201	CD	201	CD	217	BCD	205	B
9	207	CD	220	CD	217	D	220	D	220	CD	207	B
10	217	D	217	D	207	D	217	D	205	D	201	B

* Positions in the ranks with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Table 17: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between natural resources students from different European countries.

Country	n	No thinning (7000 stems/ha)		Traditional th. (5300 stems/ha)		Heavy thinning (1000 stems/ha)		Very heavy th. (300 stems/ha)		Solitary trees (100 stems/ha)	
		215	205	211	203	208	220	210	201	207	217
Denmark	53	5.21^{B}	4.57^{AB}	6.26^{A}	7.64^{A}	6.13^{A}	5.89^{A}	5.58^{AB}	5.40^{AB}	4.51^{AB}	3.81^{AB}
Austria	46	5.72^{AB}	5.87^{A}	6.02^{A}	7.69^{A}	6.38^{A}	4.24^{B}	5.43^{B}	5.13^{AB}	5.58^{A}	3.04^{B}
Portugal	45	7.24^{A}	6.22^{A}	6.27^{A}	7.46^{A}	5.93^{A}	4.57^{AB}	5.96^{AB}	4.07^{B}	3.70^{B}	3.73^{AB}
Romania	53	7.17^{A}	4.94^{AB}	5.87^{A}	7.77^{A}	6.28^{A}	4.04^{B}	5.96^{AB}	4.66^{AB}	4.68^{AB}	3.74^{AB}
Sweden	36	5.89^{B}	3.11^{B}	4.83^{A}	6.38^{A}	6.44^{A}	4.11^{B}	7.22^{A}	6.25^{A}	6.06^{A}	4.69^{A}
UK	37	4.95^{AB}	4.73^{A}	5.74^{A}	7.05^{A}	6.16^{A}	6.11^{A}	6.08^{AB}	4.66^{A}	4.69^{AB}	4.80^{A}
K-W p-value		0.000*	0.000*	0.224	0.175	0.891	0.000*	0.031*	0.003*	0.004*	0.013*

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

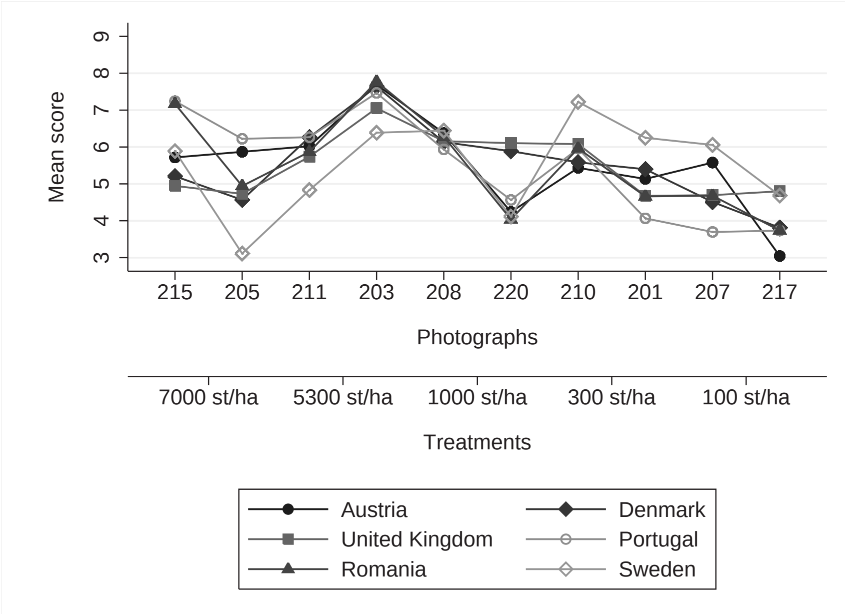


Figure 18: Picture assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of natural resources students from different European countries (highest score=10, lowest score=1).

205) were found in the top five positions, whereas the latter (picture 210, 201, 207 217) were confined in the last five positions, although not all the difference between ranking positions resulted to be statistically significant. Mid density pictures received statistically different mean score values depending on the presence or absence of a row structure: picture 208 (showing the row structure) was ranked as the second most preferred photograph, whereas picture 220 (across the direction of rows) was classified in the second last position.

A score premium for a row structure was found also among Romanian students and, to a lesser extent, among Danish students. Romanian assigned higher average scores to all photographs taken along the direction of rows, with the exception of the pair of pictures representing the 5300 stems ha^{-1} density. A preferred range of density did not emerged clearly from Romanian respondents. Dense stands (5300 stems ha^{-1}) were favoured over extremely open stands (100 stems ha^{-1}), since the former have both pictures (203 and 211) in the top five positions while the latter have both pictures (207 and 217) in the second half of the ranking. All other treatments have only one picture in the top five positions.

Portuguese students showed to prefer pictures depicting dense and very dense stands (pictures 203, 211, 215, 205) to photographs with extremely open stands (pictures 207 and 217). Like Romanian students, the Portuguese assigned a score premium for the presence of row structure, with the exception of the pair of pictures 211 and 203.

Students from Sweden presented quite a unique ranking. Differently from all other students, they selected picture 210 (300 stems ha^{-1}) as the most preferred one. In the second position, there was picture 208 and picture 203 is found only in the third position. Moreover, Swedes considered picture 205, representing a very dense stand (7000 stems ha^{-1}), as the least preferred one. This is in contrast with all other groups, which relegated to the last position pictures depicting a low or very low density stand. It must be underlined, however, that the Swedish ranking did not offer a clear image, since the average scores were quite close to each other and differences among the positions of the ranking were very often not significant (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). For instance, the first six position of the ranking did not have significantly different mean score values; likewise, no differences were found between the second and the eighth position as well as between the third and the ninth position.

British students singled out picture 203 as the most preferred one. This picture received a significantly higher score than pictures 215 and 205, representing very dense stands, as well as picture 201, 217 and 207, showing open and very open stands (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). However, British students seemed to be substantially indifferent between picture 203 and picture 211 (with the same stem density of 5300 stems ha^{-1}), pictures 208 and 220 (1000 stems ha^{-1}) as well as picture 210 (300 stems ha^{-1}).

From a graphical analysis of Figure 18, it can be noticed that some countries showed similar preference patterns. In particular, UK and Denmark followed a similar path and they distinguish themselves from other countries by grading picture 220 almost as picture 208. Analogous preferences were found between Austrian and Romanian students: their two lines followed each other quite closely, more in the intermediate densities than in the extremes. Conversely, Portugal and Sweden seemed to have symmetric preferences. On one hand, Portuguese assigned the highest scores to very dense stands (pictures 215-205), whereas Swedes attached to these the lowest scores; on the other hand, Swedes preferred open as well as very open stands (pictures 201, 207, 217) like no other country did, while Portuguese graded them poorly. As a focal point of this symmetry, mid density stand pictures (208 and 220) received approximately the same average scores.

Results from the graphical analysis were confirmed by the picture assessment presented in Table 17. In this case, the average scores assigned to a specific photograph were compared, to check whether there were statistical differences between nations (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). Significant differences in the average score were found for picture 215, 205, 220, 210, 201, 207 and 217. In contrast, preferences converged on the assessment of pictures 203 and 211 depicting high-density stands (5300 stems ha^{-1}), as well as picture 208 whose average scores ranged from 5.93 to 6.44. As suggested by the graphical analysis, no statistical differences were found between the picture average scores assigned by Austria and Romania, on one side, and Denmark and UK, on the other.

3.3.2 Preferences for treatments

Table 18 and Figure 19 illustrate recreational preferences for young oak stand treatments. Students from the six countries analyzed showed significantly different preferences for the proposed thinning practices (Kruskal-Wallis test, $\alpha = 0.05$). Consistently with the picture analysis, the traditional thinning resulted as the most preferred treatment type for recreational porpoises. On the other hand, the extremely heavy thinning was considered as the least suitable. Swedish students represented an exception to this pattern. They ranked the very heavy thinning as the best treatment and the no thinning option as the least preferred one.

Although the traditional thinning obtained the highest average score, other treatments seemed to be equally preferred to it. In other words, in all the nations investigated, the differences between the first two or three positions of the treatment ranking were not significant (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Austrian and Romanian students favoured the traditional thinning (5300 stems ha^{-1}) and the no thinning (7000 stems ha^{-1}) over the extremely heavy, very heavy and heavy thinning (100, 300 and 1000 stems ha^{-1}). Similarly, Portuguese students singled out traditional thinning and no thinning, preferring them to the very heavy and extremely heavy thinning.

Danish and British ordered the treatments in a similar way. These students showed a preference for the traditional thinning practice, but the difference between heavy thinning and the traditional thinning was not significant

Table 18: Ranking of five different precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between natural resources students from different European countries.

	Denmark		Austria		Portugal		Romania		Sweden		UK	
#	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*	St/ha	NDWD test*
1	5300	A	5300	A	5300	A	5300	A	300	A	5300	A
2	1000	AB	7000	AB	7000	A	7000	AB	5300	AB	1000	AB
3	300	BC	1000	BC	1000	B	300	BC	100	AB	300	AB
4	7000	BC	300	BC	300	BC	1000	BC	1000	B	7000	B
5	100	C	100	C	100	C	100	C	7000	B	100	B

* Positions in the ranks with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

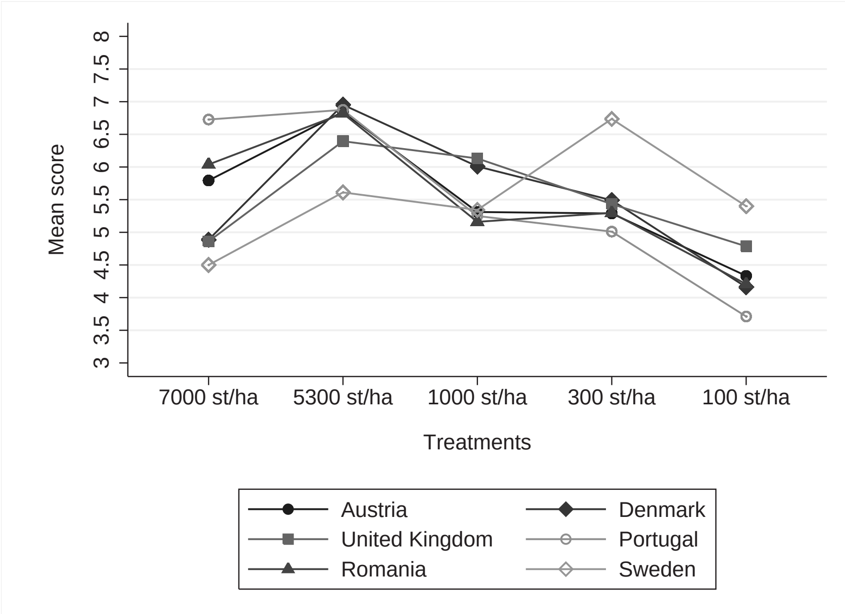


Figure 19: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: preferences of natural resources students from different European countries. (highest score=10, lowest score=1).

(Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). In the Danish case, the traditional thinning was favoured over very heavy thinning, solitary trees and no thinning. However, in the British case, the average score of the traditional thinning was strictly preferred only to extreme treatments (100 or 7000 stems ha^{-1}).

Swedish ranked the very heavy thinning, traditional thinning and extremely heavy thinning in the first three positions. The difference between the average scores was not significant (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). However, only the very heavy thinning was stringently favoured over the heavy thinning and no thinning options.

In Figure 19 it is possible to compare the patterns of recreational preferences for treatment across countries. The conclusions are similar to the ones derived from the picture analysis. The no thinning treatment had the highest average score from Portuguese students and the lowest from Swedish students. Conversely, treatments resulting in a very open stands (300-100 stems ha^{-1}) were graded higher by the Swedes and lower by the Portuguese. Aus-

Table 19: Assessment of precommercial thinning practices in even-aged stands of pedunculate oak in Denmark: comparison between natural resources students from different European countries (highest score=10, lowest score=1).

Country	n	No thinning (7000 st/ha)	Traditional thinning (5300 st/ha)	Heavy thinning (1000 st/ha)	Very heavy thinning (300 st/ha)	Solitary trees (100 st/ha)
Denmark	53	5.79^{B}	6.95^{A}	6.01^{A}	5.49^{AB}	4.16^{AB}
Austria	46	4.39^{AB}	6.84^{A}	5.31^{A}	5.29^{B}	4.33^{AB}
Portugal	44	6.73^{A}	6.88^{A}	5.25^{A}	5.01^{B}	3.71^{B}
Romania	53	6.04^{AB}	6.82^{A}	5.16^{A}	5.30^{B}	4.20^{AB}
Sweden	36	4.50^{B}	5.61^{A}	5.34^{A}	6.74^{A}	5.40^{A}
UK	38	4.86^{B}	6.39^{A}	6.13^{A}	5.43^{AB}	4.79^{AB}
K-W p-value		0.000*	0.092	0.078	0.003*	0.020*

* Significant statistical differences between respondent groups (Kruskal-Wallis test, $\alpha = 0.05$).

tria and Romania as well as Denmark and UK showed very close preference patterns. The heavy thinning, corresponding to a residual stem density of 1000 stems ha^{-1}, seemed to split the countries in two opinion groups: UK and Denmark, which assigned to it an average score around 6, and the other countries, which expressed average scores ranging between 5 and 5.5.

Formal results on the comparison between average scores could be found in Table 19. In contrast with the graphical analysis, the difference between the assessments of the traditional thinning and the heavy thinning resulted not to be statistically different (Kruskal-Wallis test, $\alpha = 0.05$). Portugal evaluated the no thinning option significantly higher than Denmark, UK and Sweden. The latter showed a significantly higher mean score than Portugal, Austria and Romania in relation to the very heavy thinning. Moreover, Denmark, UK and Sweden presented a significantly higher mean score than Portugal only in relation to extremely heavy thinning (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

3.3.3 Preferences for photo factors

A principal component factor analysis was run to investigate whether some undergoing factors were influencing recreational preferences. The analysis was run firstly for the students' dataset as a whole, and then for each

Table 20: Preferences on scene types in even aged stands of penduculate oak in Denmark resulting from the principal component factor analysis of the European natural resources students' data.

Factor no.	Scene type	Picture	Picture characteristics: stems ha^{-1}	slash presence	row structure	sky visibility	Scene mean score*
1	Open woodland	207	100	Yes	No	Yes	4.94^{B}
		217	100	Yes	No	No	
		210	300	No	No	No	
		201	300	Yes	No	Yes	
2	Forest with low accessibility	220	1000	Yes	No	No	4.82^{B}
3	Forest with row structure	208	1000	Yes	Yes	No	6.14^{A}
		215	7000	No	Yes	No	

* Scores with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

country separately in order to search for some differences in the scene perception.

Tree techniques were applied to select the number of relevant factors. The Kaiser's rule and the parallel analysis suggested the presence of three relevant factors; instead, the scree plot analysis indicated the presence of nine factors. In the end, three factors were retained. These factors all together could explain more than 65% of the total variation in the data.

Table 25 in Appendix C presents the correlation coefficients (also called factor loadings) between factors and pictures' scores, resulting from the preliminary principal component analysis. Once the relevant factors had been selected, a varimax rotation was run to facilitate the interpretation. The correlation coefficients between the rotated factors and the pictures' scores are showed in the right part of the table.

Similarly to what was done in the Danish population's and European foresters' investigations, pictures were grouped together according to their larger positive correlation coefficient with one of the three rotated factors. Then, their common characteristics were analyzed in order to identify the scene types. The results and picture's main characteristics are presented in Table 20. From this procedure, it emerged that the perception of the pictures by the European students (considered as a single group) was similar to the one found for the Danish general public.

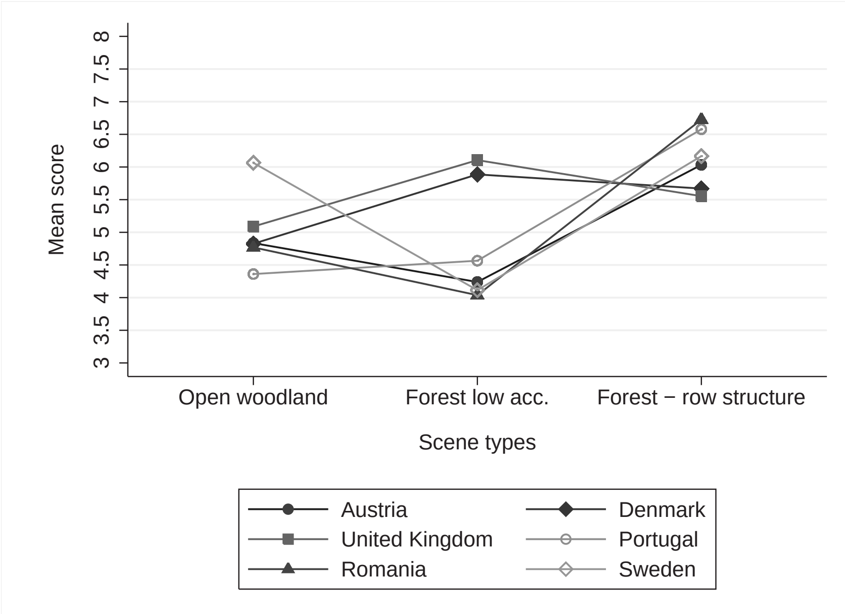


Figure 20: Preferences on scene types in even aged stands of penduculate oak in Denmark derived from the principal component factor analysis of the European natural resources students' data, average scores by country.

Factor 1, or scene type 1, was characterized by pictures 201, 207, 217 and 210. These four pictures presented similar pattern in terms of low densities and moderate presence of slash; this factor was then labelled as "open woodland". The second factor was composed by picture 208 and 215. These two photographs had in common a clear and distinct row structure. The residual stem density varied from the 1000 stems ha^{-1} of picture 208 to the 7000 stems ha^{-1} of picture 215. Slash could be observed in picture 208, but it did not harm the accessibility. This scene type was labelled "forest with a row structure". The third factor coincided with picture 220, which showed a medium density stand, without any raw structure and a significant amount of slash on the ground. This last scene type was called "forest with low accessibility".

In the last column of Table 20 is present the mean score obtained by each scene type, computed as the average of the scores of the related pictures. Overall, European students selected the "forest with a row structure" as the most preferred scene type which was favoured over the "open woodland" and "forest with low accessibility" scenes (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

Figure 20 illustrates the recreational preference for scene type for each country. Austrian, Romanian and Portuguese students favoured the "Forest with row structure" scene type, Swedish students the "open woodland" and Danish and British students preferred the "Forest with low accessibility". It is interesting to notice how the preferences for the "Forest with low accessibility" are polarized between the North-West European countries and the remaining countries. As for the treatment and picture analysis, Romania and Austria as well as UK and Denmark exhibited very close preference patterns.

So far, the results presented on the recreational preference related to scene types were referred to the overall European student dataset. In contrast, Table 21 displays the results of the factor analysis applied to each single country independently. For each nation, relevant factors were selected according to the Kaiser's rule. Pictures were grouped together according to their larger positive correlation coefficient with one of the relevant factors. Scene types' average scores were compared in the third column (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$). Finally, an interpretation of the scene type was made; when a clear path between pictures' characteristics was not found the scene type was labelled as "uncertain". Given the relatively small number of observations per country, the results should be considered with caution and as a mere, although interesting, indication.

From principal component factor analysis run at the country level, several considerations could be pointed out. Firstly, it emerged that not all the countries perceived the differences between pictures according to three factors or scene types. Namely, Austria and Romania tended to perceptually group photographs according to four factors, whose interpretation seemed not to be straightforward. Secondly, Danish students clustered pictures consistently with the grouping found for Danish experts. Thirdly, both Portugal and Sweden grouped together picture 220 and 210, which from a visual inspection seems to be distinguished from other pictures by the presence of the tree crowns in the foreground (very close to the camera optic) and by the same leaf colour. Finally, the "open woodland" scene type was perceived both in the cross-country as well as in the country specific principal component factor analysis by Sweden, Austria and Portugal. Similarly, "Forest with low accessibility" (picture 220) was detected in the cross-country factor analysis and in the Austrian one.

Table 21: Scene types of even aged stands of penduculate oak in Denmark resulting from the principal component factor analysis performed by country.

Country	Factor	Pictures	Average score*	Suggested scene type description
Denmark	Factor 1	215, 205, 203, 211	5.92^{A}	High density forest
	Factor 2	208, 220	6.01^{A}	Mid density forest
	Factor 3	210, 201, 217	4.93^{B}	Open woodland
Austria	Factor 1	201, 207, 217	3.74^{B}	Open woodland
	Factor 2	215, 210	5.58^{A}	Uncertain
	Factor 3	208	6.38^{A}	Mid density forest with row structure
	Factor 4	220	4.24^{B}	Mid density forest low accessibility
Portugal	Factor 1	208	5.93^{A}	Mid density forest with row structure
	Factor 2	201, 207, 217	3.83^{B}	Open woodland
	Factor 3	220, 210	5.26^{A}	Tree crowns in the foreground, low accessibility, similar leaf colour
Romania	Factor 1	215, 205, 203, 211	6.42^{A}	High density forest
	Factor 2	210, 207	5.34^{B}	Open woodland (uncertain)
	Factor 3	208, 220	5.16^{B}	Mid density forest
	Factor 4	201, 217	4.20^{C}	Open woodland (uncertain)
Sweden	Factor 1	201, 207, 217	5.70^{A}	Open woodland, slash lying on the ground
	Factor 2	220, 210	5.64^{A}	Tree crowns in the foreground, low accessibility, similar leaf colour
	Factor 3	205, 203, 211	4.78^{A}	High density forest
UK	Factor 1	208, 201, 207, 217	5.07^{B}	Mid to very low density forest, presence of slash but still accessible
	Factor 2	210	6.08^{AB}	Mid density forest, high understorey (uncertain)
	Factor 3	203, 220	6.58^{A}	Mid to high density forest, row structure

* Scores with the same letter are not significantly different (Nemenyi-Damico-Wolfe-Dunn test, $\alpha = 0.05$).

4 Discussion

4.1 The Danish general population recreational preferences for young oak stands treatments

Results from this study showed that the general public prefers young pendu-cultate oak stands where precommercial thinning treatments are carried out rather than unthinned stands. This is consistent with the results presented by Jensen and Skovsgaard (2009) for Denmark and supported by other investigations. Swedish and Finnish studies pointed out that precommercial thinning of boreal stands has a overall positive impact on scenic beauty. The positive effect deriving from the increased visual accessibility, in fact, more than compensates for the negative effect of thinning waste (Kardell and Holmer, 1985; Silvennoinen *et al.*, 2002). Likewise, Patey and Evans (1979) investigated recreational preferences in the United States and concluded that manipulated forest landscapes with high accessibility are aesthetically preferred over non-manipulated, dense understory landscapes.

Comparing the scores of pictures with the same stand density (Table 6, p. 42), it appeared that photographs with a row-wise structure received generally higher mean scores than pictures depicting the stand across the rows. This seems to contrast with previous findings about the Danish population, where the presence of a row structure in Norway spruce (*Picea abies* (L.) Karst.) had a negative influence on the recreational appeal of the forest scene (Jensen and Koch, 1997; Jensen, 1999). However, in this case, the preference for a row structure seems to be linked to higher stand accessibility. Actually, it can be noticed that even in the unthinned stands the photograph in the direction of rows (picture 215) has a significant higher score than the picture across the direction of rows (picture 205). Another interesting example can be observed in pictures 208 and 220. Although the same residual stem density (1000 stems ha^{-1}), the picture 220 has a significantly lower position in the ranking (Table 5, p. 41). This is most likely due to the fact that picture 208 presents a row-structure with interspaces between the trees as well as a cleaned row in the middle, looking almost like a path, increasing the visitor accessibility; while picture 220 does not. Given that pictures 208 and 220 were taken in the same stand, the quantity of slash in the ground is the same (although in the pictures it looks different). From a practical forestry point of view, this may suggest that creating some free-from-slash rows might increase the recreational appeal of stands. The only exception to this trend that suggests a preference for visitor accessibility is found in the traditional thinning stand (pictures 211 and 203). According to the author opinion, the reason behind this is the lack of row structure in picture 211 resulting in low visitor accessibility, together with a particular aesthetic quality of picture 203.

The range of preferred stand density (5300–300 stems ha^{-1}) emerged from the analysis of Jensen and Skovsgaard (2009), was confirmed by the picture analysis in this study. This result, however, presented a rather wide range of variation for the preferred residual stand density and offered a vague indication for practical forestry and forest management. The outcome suggests avoiding unthinned stands or extremely opened stands. Consequently, there was a need for implementing further analysis in order to deepen the understanding of the population's preferences: an analysis by treatments and a factor analysis were therefore conducted.

The study of preference for treatments (Section 3.1.2) was a first raw attempt to reintroduce some sort of tridimensionality in the analysis, which was somehow missing in the picture analysis. As an example, consider a visitor in the forest. In his or her visit, it is quite unlikely that the visitor always sees a tidy row structure as in picture 215 or 208. While he or she is moving, the forest scene is probably going to change. This means that the visitor may face both a distinct raw arrangement and a more irregular tree structure, as depicted in photograph 208 and 220. From Section 3.1.1, it became apparent that picture 208 and 220 are rated very differently by the general public. Although the scene might change during the visit, the residual stem number in the stand remains the same. Therefore, treatment type could be considered as a constant characteristic of forest stands.

In general, it may be inferred that shifting the focus of the analysis from pictures to treatments caused a higher level of indifference in the general public preferences compared to the results from the picture analysis. This in turn may suggest that residual stem density can vary substantially (from 5300 to 300 stems ha^{-1}) without affecting the general visitor's preferences and that other factors included in the picture (such as amount of slash, stand accessibility, canopy closure) are likely to shape preferences more in details.

Now, results from the principal component factor analysis seemed to confirm the hypothesis for which the general public apparently do not discriminate among the scenes based on treatment type. Rather, according to the result of this study, the general public respondents tended to perceptually group scenes according to similar overall patterns of openings, presence or absence of row structure, and stand accessibility. Similar results were found by Bradley *et al.* (2004) for young Douglas-fir stand treatments in the United

States. The authors concluded that respondents did not seem to discriminate among scenes based on treatment types; rather, scenes where grouped according to analogous patterns of openings, tree size variation, and colour.

Overall, the factor analysis suggested that the general public favoured a forest environment with a certain degree to canopy closure with high accessibility. As long as the stand is accessible, via a define row structure or the presence of a path (as it may seem from picture 208), the density of the stand can vary substantially without affecting preferences. The result from the picture analysis that a medium to dense forest environment is preferred over open woodland was also reinforced. Furthermore, picture 220 seems to represent what Danes would avoid to visit during their leisure time: a forest environment hard to access with a significant amount of slash on the ground. Actually, previous studies showed that the Danish general public preferred the forest floor to be cleared of logs and branches (Jensen and Koch, 1997; Jensen, 1999).

In summary, from the factor analysis it seems possible to conclude that an accessible forest environment with medium to high stem densities is the most preferred young stand type by the Danish general public. This reflects the findings from other studies focusing on Scandinavia. In his survey of the Swedish general public, Hultman (1983) showed that freshly tended young stands with visible debris received significant lower scores compared to similar stands with a path through them or with completely decayed residuals. Overall, preference studies in Fennoscandia showed that forest openness for visual accessibility is among the most important structural factors for recreation (Gundersen, 2006; Gundersen and Frivold, 2008).

A special remark must be made on picture 203. Although the accessibility in the stand depicted in it is very low and it presents a high understory of stinging nettle (*Urtica dioica*), picture 203 marked the highest mean score value. This is apparently in contrast with the idea that accessibility is a crucial property for creating young oak stands suitable for forest recreation. The reason for this anomaly may be explained considering the particular aesthetic appeal of the picture, with a ray of sun light penetrating into the canopy precisely when the picture was taken, conferring to the scene a fairy tale appearance. This delightful visual effect is not present in other photographs and it would not be surprising if this might have introduced some bias into the results. Nevertheless, it must be underlined that such type of light penetration in the stand and the consequent exquisite scene can be found only in stands with a certain degree of canopy closure. That is, what makes picture 203 admirable (i.e. light penetration in the stand) is a typical characteristic of high density stands and is absent in open woodlands. As a matter of fact, open and very open stands share similar characteristics (among which canopy closure and type of light effects) and hence were considered as a separate scene type by the general public.

Given that within a rage that varies from 5300 to 1000 or even 300 stems ha^{-1} there is a substantial indifference in preferences, it is possible to draw some implication for silviculture. According to this founding, forest managers have a certain degree of flexibility in determining the residual stem density in young stands in order to create a forest environment suitable for recreation and, at the same time, fulfil other forest management objectives. For instance, choosing a residual stem density of 5300 stems ha^{-1} seems not to lead to significantly different recreational preferences compared to a residual stem density of 1000 or 300 stems ha^{-1}. However, in dense stands the possibility of epicormic branches presence is extremely lower than in open stands. Therefore, the production of high quality timber and recreational services could be combined, given that accessibility is maintained say by a total or partial slash removal or by the creation of paths or strip roads.

Another possibility compatible with these results is suggested by Nielsen and Jensen (2007). It consists in creating a forest environment with a gradient of different densities in order to overcome to low visual accessibility of monoculture in the young stage. In other words, uniform stand of timber oaks may be mixed with a contrasting diversity of picturesque open-grown trees (Jensen and Skovsgaard, 2009). Which solution is better for a multiple objective forest management has to be further investigated considering also economical and ecological issues.

4.2 The Danish experts' preferences and the comparison with the general public's

One of the most important findings in the analysis of the experts' preferences is that respondents seemed to group pictures according to similar residual stem densities: high density forest (7000-5300 stems ha^{-1}), medium density forest (1000 stems ha^{-1}) and low density forest (300-100 stems ha^{-1}). Experts perceived treatments as three categories, grouping together very high and high density stands on one hand, and the low and very low stands on the other hand. This is not surprising, given that from a visual analysis of the ten pictures, it is not easy to distinguish between treatments with 7000 and 5300 stems ha^{-1} as well as between 300 and 100 stems ha^{-1}.

It is then possible to affirm that, differently from the general public, experts discriminate among scene types according to treatments. This is apparently in contrast with the findings by Bradley *et al.* (2004) who investigated recreational preferences of the general public, forestry professionals, educators and environmentalists. The authors concluded that the respondents, hence also forestry professionals, were not able to discern among treatment types. However, Bradley *et al.* (2004) run the principal component factor analysis on the whole dataset and hence the scene types identified were referred to a heterogeneous set of respondents. A segmentation of the dataset may have led to different conclusions.

The results from the factor analysis may shadow a tendency of educated experts to analyze and evaluate stands accordingly to the paradigms normally used in their professions, although in the questionnaire it was asked to rank according to a visitor point of view. For instance, forestry professionals and students show a preference for medium to high residual stand densities, which are the ones typically found in monoculture stands for timber production. This is reflected also in a study by Hultman (Hultman 1981, *in* Gundersen and Frivold, 2008) who affirmed that trained foresters showed a greater appreciation for scenes that have been formed in ways they had been accustomed to in their education. Furthermore, a previous study identified different attitudes towards silvicultural practices of people with different levels of knowledge and understanding about forestry (Edwards *et al.*, 2010b).

Compared to the general public, experts showed preferences with a higher degree of consistency among the different types of analysis. In other words, the pattern of experts' preferences in relationship to treatments is somehow similar to the picture assessment: in both cases, students showed a preference for the traditional thinning (high residual stem densities), foresters for the heavy thinning (medium residual stem densities) and green professionals for the very heavy thinning (low residual stem densities). This does not hold for the general public preferences: in switching from the pictures' analysis to the treatments' analysis, the preference structure changed towards a wider and more undefined set of treatments with analogous scores.

The analysis of the preferences for scene types (factor analysis) has been conducted considering expert group as a whole. It has to be noticed that these results are influenced by the size of the expert subgroups (forestry professional, green professionals and students). Actually, foresters represented about 44% of the experts group, students 39% and green professionals only 17%. Not surprisingly, the outcome of the analysis showed that a mid density forest was the most preferred scene type. By decomposing the scene type analysis by experts segments, the outcome would be similar to the treatment analysis, given that the scene types are a simplification (averaging) of the treatments' scores.

So far, the discussion has been focused on the recreational preferences of the general public, forest professionals, green professional and students on the ten young oak stands. Comparing recreational preferences of these groups has a high interest from a silvicultural and forest management point of view. Firstly, it is interesting by itself to know to which extent the ideas of forestry professionals correspond to forest users' recreational preferences. Secondly, it can shed more light on how young oak stands would look like if professionals would manage them according to forest recreation objectives without any knowledge of the population preferences.

In this regard, from the analysis it became apparent that the general public prefers accessible stands with a stem density ranging from 5300 to 1000/300 stems ha^{-1}. An interesting question would be to test which expert subgroup is able to better fulfil the recreational demand of the general public in young oak stands. This can be done with a simple "game". Consider a the pure hypothetical case in which the management option for young oak stands is decided by one of the expert subgroups and that the management option is selected via the group picture ranking. Foresters would choose a stand treatment similar to picture 208, green professional picture 201 and students picture 203. Given the picture preferences of the general public according to this analysis, only foresters and natural resource students would create a forest environment suitable for forest recreation, at least from a scenic beauty point of view (note that in Table 5 at p. 41, pictures 203 and 208 are significantly preferred by the general public to picture 201).

In this simple "game", however, the stand accessibility was not directly considered. From the factor analysis, it resulted that this valuable property was not directly contemplated as an important factor by experts, although both students and foresters assigned a score premium to picture with a row structure. In the light of these considerations, it is interesting to re-examine the outcome of the "game".

In the first case, it is true that picture 208, selected by foresters, fulfils the accessibility requirement. From this study, however, it appeared that the driving force behind this choice was more the stand density level rather than the accessibility characteristics. It is important to note that picture 208 and picture 220 were considered as the same scene type by the experts, but not by the general public. What is more, in the foresters' ranking, pictures 208, 203 and 220 were respectively at the first, second and third place, but the differences among their mean score values were not significant (Table 5, p. 41). In the second case, picture 203 — whose peculiarity has been discussed above — would have been selected by students. Again, accessibility was not considered as a compelling element. This idea is also supported by the fact that picture 203 which was ranked in the first place by students obtained a mean score value not significantly different from picture 208 and 211 (Table 5, p. 41) presenting very different degrees of accessibility.

In summary, the general findings of this comparison suggest that educated experts' recreational preferences are in part influenced by the forest management knowledge. Furthermore, professional foresters and students present similar characteristics in terms of preferred stand density for recreational purposes. However, there is the risk that implementing the management following exclusively the experts' opinions may lead to stand that are not accessible and therefore not suitable to meet the general population recreational demand. As a consequence, stand accessibility must be assured via a defined row structure, creation of strip roads or even path to enter the stands.

4.3 Recreational preferences for young oak stands treatments of forestry professionals across Europe

The ranking of pictures by each country group showed a higher degree of indifference between picture compared to the Danish population analysis and the students' analysis. Fewer significant differences within the rankings were recorded. Ranking positions were either highly overlapping (unclear boundaries between positions) or not significantly different. Moreover, a clear preference for one particular picture could not be found in any of the groups. It is believed that this was partially due to the grouping effect.

The grouping of forestry professionals according to the geographical region responded to the demand for generating a dataset able to cover the entire European continent with limited resources. From the graphical analysis of the preferences for picture within each country group (Figure 13, pp. 50–51), it appeared that within some groups there were differences between preference patterns of countries. This was particularly evident for the Southern European region and non-continental Europe. Consequently, the variance of the picture average scores is likely to have been affected by the grouping process.

Although not really pronounced, differences were found among all groups with exception of Central Europe. This group did not present any significantly different preference for a particular picture or treatment. The Kruskal-Wallis test, the ANOVA test as well as the Nemenyi-Damico-Wolfe-Dunn test were repeated excluding the Italian data, to check whether there was a noise generated by a grouping effect. The results indicated the absence of significant differences between picture preferences. Similar results were found also for Italian data. Therefore, a substantial indifference emerged also in the two main subgroups of Central European foresters' data. This means that little consensus emerged among respondents in ranked pictures. Therefore, no strong tendency was detected, resulting in very similar distribution of picture scores.

Nevertheless, some general tendency emerged from the picture analysis and, largely, from the treatment analysis. Firstly, geographical differences were found in the analysis of recreational preferences among forestry professionals in Europe. This is consistent with the findings of the student analysis and confirmed by other studies (Edwards *et al.*, 2010b,a). In particular, contrasts were found in the assessment of unthinned stands (7000 stems ha^{-1}) as well as for heavily thinned stands (1000 stems ha^{-1}).

Southern European foresters distinguished themselves for a clear preference for dense stands. This is confirmed by previous findings for the Iberian Peninsula according to which scenic beauty is considered higher in denser stands (Blasco *et al.*, 2009; Carvalho-Ribeiro and Lovett, 2011). A possible explanation for this type of preferences may be the climatic factor. As underlined by Weinstein and Schiller (1982) in their study on microclimate and forest recreation in Israel, optimum conditions for recreation prevail in well ventilated and high density stands that provide a better cooling effect for the heat load caused by radiation and air temperature.

Forestry professionals from Denmark and from non-continental Europe presented very close preference for treatments. Compared to other country groups, Denmark and non-continental Europe showed a remarkably higher predilection for heavy thinning. The same tendency is found between British and Danish natural resource students. A preference for vigorous thinning for both the general public and forestry experts was found by (Jensen, 1993) for Norway spruce stands. This feature was not found in beech (*Fagus sylvatica* L., aged 33) stands probably because of the significant amount of slash on the forest floor (Jensen, 1999). However study by (Jensen, 1999) was focused only on the Danish general public, and as discussed before, the general public considered less desirable logs and branches lying of the forest.

Analogous preferences for treatment type were found between Central Europe and Nordic countries. These two groups seemed to agree closely on the assessment of thinning practices. Both the traditional thinning (5300 stems ha^{-1}) and the very heavy thinning (300 stems ha^{-1}) appears to be favoured, although differences between average scores are not significant. Overall, preferences that emerged for these two groups did not offer an incontrovertible picture.

Interestingly, results from the factor analysis showed that the European foresters discriminate among scene types according to treatments. This is consistent with the results found for the Danish experts. As already discussed, forestry education is reflected in the scenic preferences in form of a greater appreciation for scenes that have been formed in ways foresters had been accustomed to in their education (Hultman 1981, *in* Gundersen and Frivold, 2008).

Moreover, from the principal component factor analysis it emerged that the presence of slash did not have a significant role in shaping forestry professionals preferences, whereas stand treatment did. This suggests that foresters are more willing to accept the negative and temporary effects of silvicultural intervention such as slash and wood debris (Bliss, 2000).

4.4 Recreational preferences for young oak stands treatments of natural resources students across Europe

As for the forestry professionals' case, geographical differences were found in the analysis of recreational preferences among natural resource students in Europe. This seems to be confirmed by other studies, although the literature on the comparison of public preferences for silvicultural practices in Europe is confined on few analyses. However, the presence of a spatial factor influencing recreational preferences is suggested by comparing the literature for case studies in different European countries (Edwards *et al.*, 2010b,a).

European natural resources students did not show to share similar recreational preferences for stand treatment practices in young oak. Overall, the picture analysis was not able to offer clear indications on the preferred forest environment. For most of the countries examined, picture 203 (5300 stems ha^{-1}) was selected as the most preferred one and picture 217 (100 stems ha^{-1}) as the least preferred. However, regarding the intermediate positions a distinct image did not appeared. Moreover, the top and the bottom positions often received average scores not statistically different from, respectively, the following or preceding positions.

In the picture, treatment and factor analysis, it was possible to identify a recurrent similar pattern between countries. In particular, Austrian and Romania on one hand, and UK and Denmark on the other hand, exhibited analogous preferences. The former inclined towards practices resulting into dense or very dense stands; the latter promoting traditional or heavy thinning.

This may be due to similar geographical, climatic and forest cover characteristics of the countries of origin, comparable forestry traditions and practices as well as analogous landscape types (Edwards *et al.*, 2010b; Schraml and Volz, 2009). The fact that Portugal and Sweden, situated on the extremes of the European continent, have singular and contrasting preference patterns reinforces this hypothesis. Under these circumstances, a similar cultural and educational background may characterize the perception the forest environment. This is consistent with the idea that information are able to influence aesthetic perceptions of scenes containing evidence of that information (Jensen, 2000; Hornsten, 2000).

For example, from the principal component factor analysis appeared that European students could not discriminate pictures according to treatment type. Actually, they tended to perceptually group pictures according to similar overall patterns of openings, presence or absence of row structure, and stand accessibility. However, Danish students were in fact able to perceived pictures differences according to treatment type, although in a simplified three-treatment version (Table 21, p. 76). This is not surprising since even-age oak monoculture is not a typical forest type found in countries like Portugal, Austria, Sweden (especially the northern part) or Romania. These students were probably just not familiar with it, as underlined by many comments found in the last question of the questionnaires.

Denmark and UK share the same tradition for heavy thinning in oak (Evans, 1984). In this respect, it is interesting to notice that picture 220 (1000 stems ha^{-1}) was graded significantly higher by the British and Danish students than by any other country. Generally, this photograph is considered as one of the least attractive for forest recreation due to the low accessibility (Table 16, p. 65). In most cases, it received lower scores than picture 208, also representing the heavy thinning treatment but with higher levels of accessibility. However, this did not hold for UK and Denmark, indicating a strong preference for the heavy thinning treatment itself.

Another interesting example of the influence of the national background in shaping preferences may be found in the Portuguese results. As it can be observed in Table 18 at p. 70, Portuguese singled out the traditional thinning or no thinning (5300–7000 stems ha^{-1}) as the most preferred practices. This finding is supported also by the results on Portuguese population recreational preferences presented by Carvalho-Ribeiro and Lovett (2011). As discussed for the Southern European foresters, behind this preference there might be some climatic reasons (Weinstein and Schiller, 1982). Moreover, the first five pictures in the ranking (Table 16, p. 65) are free from slash and debris on the ground (which are in general related to thinning intensity). This is significant when considered that Portugal has the highest number of forest fires in Europe (Carvalho-Ribeiro and Lovett, 2011).

Besides the cultural and educational background, another factor influencing preferences is the age of respondents (Kaplan and Kaplan, 1989; Gundersen and Frivold, 2008; Edwards *et al.*, 2010b). In this study, students' mean age was 24 years old, whereas it was 46 for the European forestry professionals and 47 for the Danish general public. Compared to the Danish population and forestry professionals' results, very dense stands scenes generally obtained higher scores. Interestingly, this preference of young respondents for denser stands is confirmed by Jensen and Skovsgaard (2009).

Swedish students, however, diverge from this trend. They selected picture 210 (300 stems ha^{-1}) as the most suitable forest environment for recreational activities and picture 205 (7000 stems ha^{-1}) as the least appropriate. This is in contrast with previous researches (Grahn, 1991; Lindhagen and Hörnsten, 2000) where it was concluded that young Swedes seem to appreciate dense forest more than they do the cultivated and open forest. However, in these studies both mature and young stand were evaluated. Mature stands with easy access are generally highest ranked by Swedes. The density of these stands is generally much lower than the density in young stands. Therefore, it is possible that in this survey Swedish students ranked in the top positions young stands with a lower density and higher accessibility; or in other words, young stands that offer the same possibilities of the mature stands in terms of recreational activities. As a matter of fact, this seems to be in line with the idea that the Swedish general population experienced young stands to be undesirable for forest recreation (Hultman, 1983; Lindhagen, 1996).

Given the increasing integration of the European labour market, it is curious to check whether today students (the future foresters or natural resource managers) from Austria, UK, Romania, Portugal and Sweden will be able to satisfy the general public recreational demand in the case they will be employed in Denmark. This is a hypothetical exercise, similar to the "game" run in the previous section. According to the picture ranking and consistently with the treatment ranking, the management option selected by all countries would be picture 203 with a stem density of 5300 stems ha^{-1}, with the exception of Sweden, which would select picture 210 representing a stem density of 300 stems ha^{-1}. Given that the general public slightly preferred picture 203 to 210 but not significantly, all groups would create a suitable forest environment. However, turning to preference for scene types and therefore accounting stand accessibility, only Romanian, Austrian and Portuguese students would create a forest environment suitable for the Danish general public's recreation.

4.5 Final remarks

Although the limitations derived from the low amount of resources in the data collection and the lack of a structured statistical design, this study was able to identified consistent results related to recreational preferences of the Danish population. Moreover, it was able to shed more light on two issues not frequently discussed in the literature: recreational preferences on young stands practices as well as the pan-European comparison of recreational preferences. In the two international analyses, similar patterns were identified within and between countries.

Some methodological considerations emerged from this analysis should be taken into account in future studies. Firstly, the use of one questionnaire for both the general public and the experts was a sort of limitation for this study and therefore it should be avoided.

Secondly, explicit questions about the professions, the background in silviculture, the present landscape type, the postal code and the landscape type of the childhood of the respondents would be very helpful in the analysis.

Thirdly, picture ranking has the advantage that it is a quick way to investigate preferences, but it does not give indication on "by how much" a scene is preferred to another. Ranking can be transformed into rating but results must be interpreted with caution. Therefore, direct rating of picture on say a 1–10 scale might be considered. Moreover, it would be interesting to compare the opinion of the population on both the recreational, production and conservation values of a set of forest scenes asking to rate or rank picture according to these different management objectives.

Fourthly, with the modern technique investigating preferences through visual stimuli is becoming more flexible. Especially for international surveys, the questionnaire could be submitted on-line and the visual stimuli presented on a computer screen. Furthermore, picture could be easily modified in order to control for the presence or absence of slash and ground vegetation as well as for the colour of the sky. In this way, the control over the pictures' characteristics is higher and the experimental design more accurate.

Fifthly, as it was done in this study, the places where picture are taken should be permanently marked in order to facilitate the investigation of changing in preferences according to the stands' development. On this regard, it would be interesting to present to the respondent the pictures depicting the mature stage of each forest scene in the analysis, in order to analyze whether information on the future development of the stands could affect preferences.

Finally, in the author's opinion, the analysis of international preferences should be done at the country level, but preferably at sub-country level and according to landscape type. As a matter of fact, recreational preferences are thought to change significantly even over short distances (Jensen and Koch, 1998).

5 Conclusions

This study was aimed to analyze recreational preferences for different thinning practices in young penduculate oak stand. The analysis was developed on three different datasets. In the first dataset, the general public's preferences and the experts' preferences were compared for Denmark. In the second and the third dataset, recreational preferences of forestry professionals and natural resources students were investigated across Europe. For each dataset, preferences were investigated for pictures, treatments, and photo factors or scene types.

As far as the Danish population is concerned, significant differences were observed among groups of respondents. Natural resources students showed a preference for the traditional thinning (7000 stems ha^{-1}), foresters for the heavy thinning (1000 stems ha^{-1}), and green professionals for the very heavy thinning (300 stems ha^{-1}). The general public showed a wider range of preferred stand density (5300–300 stems ha^{-1}). Interestingly, picture with a row-wise structure received generally higher mean scores than pictures depicting the stand across the rows.

Danish experts showed preferences with a higher degree of consistency among the different types of analysis (by picture and by treatment) when compared to the general public. The preference structure, in fact, changed towards a wider and more undefined set of treatments with analogous score in switching from the pictures analysis to the treatments analysis.

Results from the principal component factor analysis showed that the general public seemed not to discriminate among the pictures based on treatment type. Rather, the general public respondents tended to perceptually group scenes according to similar overall patterns of openings, presence or absence of row structure, and stand accessibility. On the contrary, Danish experts seemed to perceptually group pictures according to treatment type. In summary, from the factor analysis it seems possible to conclude that an accessible forest environment with medium to high stem densities is the most preferred young stand type by the Danish general public.

According to these findings, it is possible to draw some implication for silviculture for tending young penduculate oak stand in Denmark. Given the wide range of preferred stand density (5300–300 stems ha^{-1}), forest managers have a certain degree of flexibility in determining the residual stem density in young stands in order to create a forest environment suitable for recreation and, at the same time, fulfil other forest management objectives.

However, the impression is that Danish experts did not perceive stand accessibility as importantly as the general public does. Results from this works suggests that following exclusively the experts' opinions in implementing the management of young stands may lead to stands that are not accessible and therefore not suitable to meet the general public's recreational demand. Consequently, stand accessibility should be assured, for example, via a defined row structure, partial or total removal of slash or the creation of strip roads or small path.

Turning to the analysis of forestry professionals across Europe, geographical differences have been found in the analysis of recreational preferences. In particular, contrasts were found in the assessment of unthinned stands (7000 stems ha^{-1}) as well as for heavily thinned stands (1000 stems ha^{-1}). Southern European foresters distinguished themselves for ranking dense stands higher, whereas Danish and non-continental European forestry professionals showed a remarkably higher predilection for heavy thinning compared. Similar results emerged also in the comparison of natural resources students across Europe, for Portugal, Denmark and UK, respectively.

Consistently with the results found for the Danish experts, the principal component factor analysis showed that the European foresters discriminate pictures according to treatment types. The presence of slash did not have a significant role in shaping forestry professionals preferences, whereas stand treatment did. This suggests that foresters are more willing to accept the negative and temporary effects of thinning intervention such as slash and wood debris.

Regarding the analysis of preferences of natural resource students for young oak stand treatments, significant differences were found between country groups. Generally, it was possible to identify a recurrent preference pattern between countries. In particular, Austrian and Romania on one hand, and UK and Denmark on the other hand, exhibited analogous preferences. The former inclined towards practices resulting into dense or very dense stands; the latter promoting traditional or heavy thinning. Conversely, Portugal and Sweden seems to present symmetric preferences. On one hand, Portuguese assigned the highest scores to very dense stands (7000 stems ha^{-1}) and the graded poorly open as well as very open stands (300–100 stems ha^{-1}), whereas Swedes did exactly the opposite.

From the principal component factor analysis across European students, it emerged that respondents could not discriminate pictures according to treatment type. Similarly to the Danish general public, they tended to perceptually group pictures according to overall patterns of openings, presence or absence of row structure, and stand accessibility. This may have been due to the fact students from Portugal, Austria, Sweden (especially the northern part) or Romania were not familiar with even-age oak monoculture. This idea seemed reinforced by the fact that Danish forestry students, who are accustomed with this type stands, perceived pictures differences according to treatment type.

Acknowledgments

I am sincerely grateful to my supervisors, Jens Peter Skovsgaard and Frank Søndergaard Jensen for their stimulating suggestions and comments as well as for the enthusiasm they showed for this work.

I am thankful to Norocel-Valeriu Nicolescu at the University of Brasov, Margarida Tomé and Paula Soares at the Technical University of Lisbon, Paola Gatto at the University of Padua, Ulrike Pröbstl, Hubert Hasenauer and Roland Berger at the University of Natural Resources and Applied Life Sciences of Vienna, Arne Pommerening at Bangor University and Göran Hallsby at SLU in Umeå for their patience and fantastic help with the surveys.

I wish to thank the people at the Southern Swedish Forest Research Centre in Alnarp for their assistance. In particular, special gratitude is reserved to Per Magnus Ëko and Erik Agestam for their scientific support and to Giulia Attocchi for her generous contribution regarding experiment 1516.

Further thanks to Andrea Martini, Luca Colomban and Francesco Bizzotto who offered me pure "re-creational" moments despite the spatial distance. My sincere appreciation to my family for their irreplaceable support and understanding. I also wish to thank all the people not mentioned so far but who deserve to be here for their friendship and encouragement. Finally, I want to express my deepest gratitude to my dear Valentina for her extraordinary intellectual assistance, language advice and for her unique ability of filling my days with joy.

References

Ammer, U. (2000). Comments on Primary Afforestation in Bavaria - Summary. In N. Weber, editor, *NEWFOR - new forests for Europe: afforestation at the turn of the century. Proceedings of the Scientific Symposium, 16–17 February, Freiburg, Germany*, pages 23–50. EFI Proceeding no. 35, EFI, Joensuu.

Arriaza, M., Cañas-Ortega, J., Cañas-Madueño, J., and Ruiz-Aviles, P. (2004). Assessing the visual quality of rural landscapes. *Landscape and Urban Planning*, **69**, 115–125.

Attocchi, G. (2011). Map of experiment no. 1516. Southern Swedish Forest Research Centre, SLU, Alnarp. (Unpublished).

Beckwith, J., Moore, S., Clement, S., Curnow, B., and Admiraal, R. (2010). The impact of forest thinning on perceptions of recreational value and forest health. Technical report prepared as part of the wungong catchment research trial, Beckwith Environmental Planning and Murdoch University and Perth.

Blasco, E., González-Olabarria, J., Rodriguéz-Veiga, P., Pukkala, T., Kolehmainen, O., and Palahí, M. (2009). Predicting scenic beauty of forest stands in Catalonia (North-east Spain). *Journal of Forestry Research*, **20**, 73–78. 10.1007/s11676-009-0013-3.

Bliss, J. (2000). Public perceptions of clearcutting. *Journal of Forestry*, **98**, 4–9.

Bradley, G. A. and Kearney, A. R. (2007). Public and professional responses to the visual effects of timber harvesting: Different ways of seeing. *Western Journal of Applied Forestry*, **22**, 42–53.

Bradley, G. A., Kearney, A. R., and Wagar, J. A. (2004). Public reactions research. In R. O. Curtis, D. D. Marshall, and D. S. DeBell, editors, *Silvicultural Options for Young- Growth Douglas-Fir Forests: The Capitol Forest Study - Establishment and First Results*, number PNW-GTR-598 in General Technical Report, chapter 7, pages 63–73. U.S. Department of Agriculture, Forest Service - Pacific Northwest Research Station.

Brown, T. and Daniel, T. (1984). Modeling forest scenic beauty: concepts and applications to ponderosa pine. Res. Pap. RM-RP-256, Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Brunson, M. and Shelby, B. (1992). Assessing recreational and scenic quality: How does "new forestry" rate? *Journal of Forestry*, **90**, 37–41.

Carvalho-Ribeiro, S. M. and Lovett, A. (2011). Is an attractive forest also considered well managed? Public preferences for forest cover and stand structure across a rural/urban gradient in northern Portugal. *Forest Policy and Economics*, **13**, 46–54.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioural Research*, **1**, 245–276.

Daniel, T. C. (2001). Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning*, **54**, 267–281.

Daniel, T. C. and Boster, R. S. (1976). Measuring landscape esthetics: The scenic beauty estimation method. Research Paper RM-167, USDA Forest Service.

Daugaviete, M. (2000). Afforestation of agricultural land in Latvia. In N. Weber, editor, *NEWFOR - new forests for Europe: afforestation at the turn of the century. Proceedings of the Scientific Symposium, 16–17 February, Freiburg, Germany*, pages 23–50. EFI Proceeding no. 35, EFI, Joensuu.

du Breil de Pontbriand, L. (2000). European Experiences with Regulation 2080/92 and the New Afforestation Policy under Agenda 2000. In N. Weber, editor, *NEWFOR - new forests for Europe: afforestation at the turn of the century. Proceedings of the Scientific Symposium, 16–17 February, Freiburg, Germany*, pages 23–50. EFI Proceeding no. 35, EFI, Joensuu.

Edwards, D., Jay, M., Jensen, F. S., Lucas, B., Marzano, M., Montagne, C., Peace, A., and Weiss, G. (2010a). Assessment of the recreational value of European forest management alternatives. EFORWOOD Deliverable D2.3.6, Forest Research, UK.

Edwards, D., Jay, M., Jensen, F. S., Lucas, B., Marzano, M., Montagne, C., Peace, A., and Weiss, G. (2010b). Public preferences for silvicultural attributes of European forests. EFORWOOD Deliverable D2.3.3, Forest Research, UK.

EUROSTAT (2009). Forestry statistics. Pocketbooks, EUROSTAT, Luxembourg.

Evans, J. (1984). *Silviculture of broadleaved woodland*. Forestry Commission bulletin. Her Majesty's Stationery Office.

Findley, A. J., Carroll, M. S., and Blatner, K. A. (2001). Social complexity and the management of small-diameter stands. *Journal of Forestry*, **99**, 18–27.

Franklin, S., Gibson, D., Robertson, P., Pohlmann, J., and Fraish, J. (1995). Parallel analysis: A method for determining signficant principal components. *Journal of Vegetation Science*, **6**, 99–106.

Grahn, P. (1991). The meaning and significance of urban parks. Dissertation Stad and Land 93, Swedish University of Agricultural Sciences, Department of Landscape Planning, Alnarp. (in Swedish, with English summary).

Greenough, J. B. (1900). *Bucolics, Aeneid, and Georgics Of Vergil*. Boston. Ginn & Co.

Gundersen, P. (2006). Management of urban recreational woodlands: The case of norway. *Urban Forestry & Urban Greening*, **5**, 73–82.

Gundersen, V., Frivold, L. H., Löfström, I., Jørgensen, B. B., Falck, J., and Øyen, B.-H. (2005). Urban woodland management – The case of 13 major Nordic cities. *Urban Forestry & Urban Greening*, **3**(3-4), 189 – 202.

Gundersen, V. S. and Frivold, L. H. (2008). Public preferences for forest structures: A review of quantitative surveys from Finland, Norway and Sweden. *Urban Forestry & Urban Greening*, **7**, 241–258.

Harman, H. H. (1976). *Modern Factor Analysis*. University Chicago Press.

Hoffman, R. E. and Palmer, J. F. (1996). Silviculture and forest aesthetics within stands. Technical report, USDA Forest Service, Northeast Experiment Station (Burlington, Vermont) Northeast Decision Model Project. Published by The New York Center for Forestry Research and Development. Accessed on April 9, 2011, `http://brownrecluse.uvm.edu/envnr/greenforestry/LIBRARYFILES/Forest_Aesthetics.pdf`.

Hollander, M. and Wolfe, D. A. (1999). *Nonparametric statistical methods*. Wiley, New York.

Hornsten, L. (2000). *Outdoor Recreation in Swedish Forests - Implications for Society and Forestry*. Ph.D. thesis, Swedish University of Agricultural Sciences.

Hull, R. I. and Stewart, W. P. (1992). Validity of photo-based scenic beauty judgments. *Journal of Environmental Psychology*, **12**, 101–114.

Hultman, S. (1983). Public judgement of forest environments as recreation areas. 2. A national survey. Report 28, Section of Environmental Forestry, Swedish University of Agricultural Sciences, Uppsala. (in Swedish, with English summary).

Jensen, F. S. (1993). Landscape managers' and politicians' perception of the forest and landscape preferences of the population. *Forest and Landscape Research*, **1**, 79–93.

Jensen, F. S. (1999). Forest recreation in Denmark from the 1970s to the 1990s. The Research Series 26, Danish Forest and Landscape Research Institute, Hørsholm. 166 pp.

Jensen, F. S. (2000). The effects of information on Danish forest visitors' acceptance of various management actions. *Forestry*, **73**(2), 165–172.

Jensen, F. S. and Koch, N. E. (1997). Friluftsliv i skovene 1976/77–1993/94. Forskningsserien 20, Forskningscentret for Skov & Landskab, Hørsholm. 215 pp.

Jensen, F. S. and Koch, N. E. (1998). Measuring forest preferences of the population a danish approach. In D. Terrasson, editor, *Public perception and attitudes of forest owners towards forest in Europe*, pages 39–82. Cemagref Editions.

Jensen, F. S. and Skovsgaard, J. P. (2009). Precommercial thinning of pedunculate oak: Recreational preferences of the population of Denmark for different thinning practices in young stands. *Scandinavian Journal of Forest Research*, **24**, 28–36.

Jolliffe, I. (2002). *Principal components analysis*. Springer, second edition.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, **20**, 141–151.

Kaplan, R. and Kaplan, S. (1989). *The experience of nature: a psychological perspective*. Cambridge University Press, New York, NY.

Kardell, L. and Holmer, M. (1985). Friluftslivets förändringar på Bogesundslandet 1969–1982. Rapport 33, Avdelningen för landskapsvård, Sveriges Lantbruksuniversitet.

Karjalainen, E. and Komulainen, M. (1998). Field afforestation preferences: A case study in northeastern Finland. *Landscape and Urban Planning*, **43**, 79–90.

Karjalainen, E. and Tahvanainen, L. (2002). Visualization in forest landscape preference research: a Finnish perspective. *Landscape and Urban Planning*, **59**, 13–28.

Kassioumis, K., Papageorgiou, K., Christodoulou, A., Blioumis, V., Stamou, N., and Karameris, A. (2004). Rural development by afforestation in predominantly agricultural areas: issues and challenges from two areas in Greece. *Forest Policy and Economics*, **6**(5), 483 – 496. The Future of European Forestry - Between Urbanization and Rural Development.

Konijnendijk, C. C. (2000). Adapting forestry to urban demands – role of communication in urban forestry in europe. *Landscape and Urban Planning*, **52**(2-3), 89 – 100.

Konijnendijk, C. C. (2003). A decade of urban forestry in europe. *Forest Policy and Economics*, **5**(2), 173 – 186. Diamonds from the European Forest Institute . Evaluation of 10 Years Research in European Forestry Issues.

Löf, M., Thomsen, A., and Madsen, P. (2004). Sowing and transplanting of broadleaves (fagus sylvatica l., quercus robur l., prunus avium l. and crataegus monogyna jacq.) for afforestation of farmland. *Forest Ecology and Management*, **188**(1-3), 113 – 123.

Lindhagen, A. (1996). An approach to clarifying public preferences about silvicultural systems: A case study concerning group selection and clearcutting. *Scandinavian Journal of Forest Research*, **11**(1), 375–387.

Lindhagen, A. and Hörnsten, L. (2000). Forest recreation in 1977 and 1997 in sweden: changes in public preferences and behaviour. *Forestry*, **73**(2), 143–153.

Madsen, L. M. (2003). New woodlands in Denmark: The role of private landowners. *Urban Forestry Urban Greening*, **1**, 185–195.

Marey-Pérez, M. and Rodríguez-Vicente, V. (2009). Forest transition in Northern Spain: Local responses on large-scale programmes of field-afforestation. *Land Use Policy*, **26**(1), 139 – 156. Formalisation of Land Rights in the South.

Nielsen, A. B. and Jensen, R. B. (2007). Some visual aspects of planting design and silviculture across contemporary forest management paradigms - perspectives for urban afforestation. *Urban Forestry & Urban Greening*, **6**(3), 143 – 158.

Ode, Å. K. and Fry, G. L. (2002). Visual aspects in urban woodland management. *Urban Forestry & Urban Greening*, **1**(1), 15 – 24.

O'Leary, T. N. and McCormack, A. G. (1998). Development of a trans-european public concerning forest landscape issues: A reflection of current research needs. In D. Terrasson, editor, *Public perception and attitudes of forest owners towards forest in Europe. Perception publique et attitudes des propriétaires envers la forêt en Europe. Commentaires et synthéses du groupe de travail COST E3-WG1*, pages 207–232. Antony Cemagref Editions.

Ovando, P., Campos, P., Calama, R., and Montero, G. (2010). Landowner net benefit from stone pine (pinus pinea l.) afforestation of dry-land cereal fields in valladolid, spain. *Journal of Forest Economics*, **16**(2), 83 – 100.

Paris, J. (1972). The citification of the forest. *Canadian Pulp and Paper Magazine*, **9**, 119–122.

Patey, R. C. and Evans, R. M. (1979). Identification of scenically preferred forest landscapes. In H. Elsner and R. Smardon, editors, *Proceedings of Our National Landscape*, number PSW-35 in General Technical Report, Incline Village, NV. U.S.D.A Forest Service, Pacific Southwest Forest and Range Experiment Station.

R Development Core Team (2011). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Rey Benayas, J. M. (1998). Growth and survival in Quercus ilex L. seedlings after irrigation and artificial shading on Mediterranean set-aside agricultural land. *Annales des Sciences Forèstieres*, **55**, 801–807.

Ribe, R. G. (1989). The aesthetics of forestry: What has empirical preference research taught us? *Environmental Management*, **13**, 55–74.

Ribe, R. G. (2002). Is scenic beauty a proxy for acceptable management? The influence of environmental attitudes on landscape perceptions. *Environment and Behavior*, **34**(6), 757–780.

Rogge, E., Nevens, F., and Gulinck, H. (2007). Perception of rural landscapes in Flanders: Looking beyond aesthetics. *Landscape and Urban Planning*, **82**, 159–174.

Roovers, P., Hermy, M., and Gulinck, H. (2002). Visitor profile perceptions and expectations in forest from a gradient of increasing urbanisation in central Belgium. *Landscape and Urban Planning*, **59**, 129–145.

Rosenqvist, L. (2007). *Afforestation of arable land in north-western Europe Ű nitrate leaching, carbon sequestration and water recharge*. Acta universitatis agriculturae sueciae 2007:2, Swedish University of Agricultural Sciences.

Rune, F. and Skovsgaard, J. P. (2007). Afforestation with oak: Effects of pre-commercial thinning on the development of ground flora. In G. Halldorsson, E. S. Oddsdottir, and O. Eggertsson, editors, *Effects of afforestation on ecosystems, landscape and rural development. Proceedings of the AFFORNORD conference, Reykholt, Iceland, June 18Ű22, 2005.*, pages 203–209. TemaNord 2007: 508.

Sayadi, S., Gonzalez Roa, M. C., and Calatrava Requena, J. (2005). Ranking versus scale rating in conjoint analysis: Evaluating landscapes in mountainous regions in southeastern Spain. *Ecological Economics*, **55**, 539–550.

Schraml, U. and Volz, K.-R. (2009). Do species matter? Valuable broadleaves as an object of public perception and policy. In H. Spiecker, S. Hein, K. Makkonen-Spiecker, and M. Ties, editors, *Valuable Broadleaved Forests in Europe*, pages 213–236. S. Brill, Leiden, Boston, Köln.

Shelby, B., Thompson, J. R., Brunson, M., and Johnson, R. (2005). A decade of recreation ratings for six silviculture treatments in Western Oregon. *Journal of Environmental Management*, **75**, 239Ű–246.

Silvennoinen, H., Pukkala, T., and Tahvanainen, L. (2002). Effects of cuttings on the scenic beauty of a tree stand. *Scandinavian Journal of Forest Research*, **17**, 263–272.

Sondag, V. (1999). Forestry measures under the common agricultural policy. In *Agriculture, Environment, Rural Development: Facts and Figures - A Challenge for Agriculture*. European Commission - EUROSTAT - the Agriculture DG and the Environment DG. Accessed on April 9, 2011, `http://ec.europa.eu/agriculture/envir/report/en/forest_en/report.htm`.

StataCorp. (2007). *Stata Statistical Software: Release 10*. College Station, TX: StataCorp LP.

Stewart, T. R., Middleton, P., Downton, M., and Ely, D. (1984). Judgments of photographs vs. field observations in studies of perception and judgment of the visual environment. *Journal of Environmental Psychology*, **4**(4), 283 – 302.

Tahvanainen, L., Tyrväinen, L., Ihalainen, M., Vuorela, N., and Kolehmainen, O. (2001). Forest management and public perceptions – visual versus verbal information. *Landscape and Urban Planning*, **53**(1-4), 53 – 70.

The Council of the European Communities (EEC) (1992). Council Regulation No 2080/92 of 30 June 1992 instituting a Community aid scheme for forestry measures in agriculture. Accessed on April 9, 2011, `http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992R2080:en:NOT`.

Tips, W. and Savasdisara, T. (1986a). The influence of the environmental background of subjects on their landscape preference evaluation. *Landscape and Urban Planning*, **13**, 125–133.

Tips, W. and Savasdisara, T. (1986b). The influence of the socioeconomic background of subjects on their landscape preference evaluation. *Landscape and Urban Planning*, **13**, 225–230.

Tyrväinen, L., Konijnendijk, R. G. C., and Åsa Ode (2006). Visualization and landscape laboratories in planning, design and management of urban woodlands. *Forest Policy and Economics*, **8**, 811–823.

Valkonen, S. (2008). Survival and growth of planted and seeded oak (quercus robur l.) seedlings with and without shelters on field afforestation sites in finland. *Forest Ecology and Management*, **255**(3-4), 1085 – 1094.

Van Herzele, A. (2006). A forest for each city and town: Story lines in the policy debate for urban forests in Flanders. *Urban Studies*, **43**, 673Ű–696.

van Rensburg, T. M., Mill, G. A., Common, M., and Lovett, J. (2002). Preferences and multiple use forest management. *Ecological Economics*, **43**, 231–244.

Vesterdal, L., Ritter, E., and Gundersen, P. (2002). Change in soil organic carbon following afforestation of former arable land. *Forest Ecology and Management*, **169**(1-2), 137 – 147.

Wattenbach, M., Zebisch, M., Hattermann, F., Gottschalk, P., Goemann, H., Kreins, P., Badeck, F., Lasch, P., Suckow, F., and Wechsung, F. (2007). Hydrological impact assessment of afforestation and change in tree-species composition – A regional case study for the Federal State of Brandenburg (Germany). *Journal of Hydrology*, **346**(1-2), 1 – 17.

Weber, N., editor (2000). *NEWFOR - new forests for Europe: afforestation at the turn of the century. Proceedings of the Scientific Symposium, 16–17 February, Freiburg, Germany*. EFI Proceeding no. 35. EFI, Joensuu.

Weinstein, A. and Schiller, G. (1982). Microclimate, recreational value and management for recreation of mediterranean oak scrub. *Forest Ecology and Management*, **4**(4), 333 – 340.

Winter, C. (2005). Preferences and values for forests and wetlands: a comparison of farmers, environmentalists and the general public in Australia. *Society and Natural Resources*, **18**(6), 541–555.

Zanchi, G., Thiel, D., Green, T., and Lindner, M. (2007). Afforestation in Europe. Impact of Environmental Agreements on the CAP MEACAP WP4, SIXTH FRAMEWORK PROGRAMME – PRIORITY 8: Policy-Oriented Research. Accessed on April 12, 2011, `http://www.ieep.eu/assets/298/wp4_nd_afforestation_in_europe.pdf`.

Zar, J. (1999). *Biostatistical analysis*. Prentice Hall, Upper Saddle River, NJ., 4th edition.

Zube, E., Sell, J., and Taylor, J. (1982). Landscape perception: research, application and theory. *Landscape Planning*, **9**, 1–33.

A Appendix: the questionnaire

Forest and Landscape Denmark
Hørsholm Kongevej 11
DK-2970 Hørsholm

Response no. SLU2011

Questionaire

1. **WHEN DID YOU LAST VISIT A FOREST?**
(even short drives or walks count as a visit to a forest, if the purpose, fully or partially, was to get to or be in the forest)

(only one tick, please)

☐ Today
☐ Less than one week ago
☐ 1 to 2 weeks ago
☐ 2 to 4 weeks ago
☐ 1 to 2 months ago
☐ 2 to 4 months ago
☐ 4 to 12 months ago
☐ More than 1 year ago

2. **HOW MANY TIMES DID YOU VISIT A FOREST DURING THE PAST YEAR?**
(even short drives or walks count as a visit to a forest, if the purpose, fully or partially, was to get to or be in the forest)

....
please indicate the number of **visits within the past year**

3. **WHICH FOREST ENVIRONMENT DO YOU PREFER AS A VISITOR?**
In the ***red*** *envelope you will find 10 photographs of different forest environments. Please write the number of the forest environment that you best prefer next to* "1st preference"*, the environment that you second best prefer next to* "2nd preference"*, and so on, until the one you least prefer.*
Please rank all 10 photographs using the 3-digit number in the upper right corner of the photograph.

The forest environment that I prefer the **most** 1st preference: __ __ __ (*Photo no.)*
2nd preference: __ __ __
3rd preference: __ __ __
4th preference: __ __ __
5th preference: __ __ __
6th preference: __ __ __
7th preference: __ __ __
8th preference: __ __ __
9th preference: __ __ __
The forest environment that I prefer the **least** 10th preference: __ __ __

P.S.: The photographs can be difficult to rank. It is important for the investigation that you rank all 10 photographs.

4. **WHERE DID YOU SPEND MOST OF YOUR CHILDHOOD (0-14 YEARS)?**
(only one tick, please)

- ☐ In the countryside or in a village
- ☐ In a minor town (population less than 10,000)
- ☐ In a larger town (population more than 10,000)
- ☐ In a major city (population more than 1,000,000)

5. **ARE YOU, OR HAVE YOU PREVIOUSLY BEEN EMPLOYED, WITHIN FORESTRY, AGRICULTURE, HORTICULTURE, NATURE ADMINISTRATION OR SIMILAR?**

	YES presently	YES previously	No	
Forestry	☐	☐	☐	*(only one tick, please)*
Other 'green' job	☐	☐	☐	*(only one tick, please)*

6. **PLEASE INDICATE YOUR SEX:**
(only one tick, please)

- ☐ Male
- ☐ Female

7. **PLEASE INDICATE YOUR AGE:**

………… years

8. IF YOU HAVE COMMENTS OR SUGGESTIONS, PLEASE WRITE HERE:

....

....

THANKS FOR HELPING US

B Appendix: the principal component factor analysis

According to Jolliffe (2002), factor analysis is based on the idea that p observed random variables can be expressed, except for an error term, as linear functions of m (lower than p) latent factors. Formally, it can be written that:

$$\mathbf{x} = \Lambda \mathbf{f} + \mathbf{e}, \tag{1}$$

where $\mathbf{x}$ is the vector of p variables, Λ is the $(p \times m)$ matrix of constants called "factor loadings", $\mathbf{f}$ is the vector of factors and $\mathbf{e}$ is the vector of error terms. The factor model described in equation (1) apparently looks like a regression model. However, there is a substantial difference from the regression analysis, namely that $\mathbf{f}$ in (1) is unknown and the solution is not unique (indeterminacy). Therefore, the estimation of the model is usually done in two steps. In the first, some restrictions are placed on Λ in order to find a unique initial solution. In the second, other solutions can be found by rotation of the matrix of factor loadings (Λ) in the multidimensional space. The "best" of these rotated solutions is finally chosen according to some particular criterion (Jolliffe, 2002).

Often, the results from the principal component analysis are used as the initial solution. This particular case of factor analysis is called "principal component factor analysis". To summarize, it can be implemented as follow:

- a principal component analysis is run;
- the relevant factors are selected;
- a rotation of the factor axes is implemented;
- results are interpreted.

A principal component analysis is a mathematical procedure used to reduce the dimensionality of the dataset consisting of correlated variables by converting it into a set of uncorrelated variables called principal components or factors. This transformation is done in such a way that the variation present in the original dataset is retained as much as possible. To put it more simply, the first few components retain most of the variation present in all of the original variables. In particular, the first principal component has the highest possible variance (that is, accounts for as much of the variability in the data as possible); the second principal component, in turn, has the highest variance as possible under the constraint that it has to be orthogonal to the first component; similarly for each succeeding principal components. The total number of principal component can be as maximum equal to the number of the original variables (Jolliffe, 2002).

For example, consider a vector $\mathbf{x}$ of p random variables. Following Jolliffe (2002), the first step of a principal component analysis is to look for a linear function $\alpha_1'\mathbf{x}$ of elements of $\mathbf{x}$ with the highest possible variance:

$$\alpha_1'\mathbf{x} = \alpha_{11}x_1 + \alpha_{12}x_2 + \cdots + \alpha_{1p}x_p = \sum_{j=1}^{p} \alpha_{1j}x_j \tag{2}$$

where α_1 is a vector of constants α_{11}, α_{12}, ..., α_{1p}. The following step is to look look for a second linear function $\alpha_2'\mathbf{x}$ uncorrelated with $\alpha_1'\mathbf{x}$ having maximum variance. This procedure is going to be repeated up to p times. In general, at the kth step the objective is to find a linear function $\alpha_k'\mathbf{x}$ uncorrelated to all the previous $k-1$ linear functions. The linear functions $\alpha_1'\mathbf{x}$, $\alpha_2'\mathbf{x}$, ..., $\alpha_k'\mathbf{x}$, are respectively the first, second and kth principal components.

Formally, the first principal component, $\mathbf{f}_1$, is derived by finding the vector α_1 that maximizes the variance of the linear transformation $\alpha_1'\mathbf{x}$ under some normalization constraint (otherwise the maximum would not be achieved for finite α_1). The maximization problem can be written as:

$$\max_{\alpha_1} \operatorname{var}(\alpha_1'\mathbf{x}) \tag{3}$$

$$s.t.\, \alpha_1'\alpha_1 = 1.$$

In matrix notation the variance of $\alpha_1'\mathbf{x}$ can be written as:

$$\operatorname{var}(\alpha_1'\mathbf{x}) = \alpha_1'\Sigma\alpha_1, \tag{4}$$

where Σ is the covariance matrix of the vector of variables $\mathbf{x}$. The constraint used in the derivation states that the sum of squares element of α_1 must be equal to 1. To solve the maximization problem the following expression must be differentiated by α_1:

$$\alpha_1'\Sigma\alpha_1 - \lambda\left(\alpha_1'\alpha_1 - 1\right), \tag{5}$$

which gives the following optimal condition:

$$\left(\Sigma - \lambda\mathbf{I}_p\right)\alpha_1 = 0, \tag{6}$$

Figure 21: Graphical representation of the principal components, f_1 and f_2, in a two-dimension dataset consisting of two variables, x_1 and x_2.

where $\mathbf{I}_p$ is the $(p \times p)$ identity matrix. From (6) it emerges that λ is an eigenvalue of Σ and α_1 is the corresponding eigenvector. Now, it remains to select which one of the p eigenvectors maximize the variance of $\alpha_1'\mathbf{x}$. Note that the quantity to be maximize is:

$$\alpha_1'\Sigma\alpha_1 = \alpha_1'\lambda\alpha_1 = \lambda, \tag{7}$$

therefore, λ must be as large as possible. Consequently, α_1 is the eigenvector corresponding to the largest eigenvalue of Σ; it follows that var($\alpha_1'\mathbf{x}$)=λ_1.

The derivation of the second, third up to the pth component is analogous to the one just presented, with the inclusion of an additional constraint assuring that the principal components are orthogonal. In general, it can be showed that the kth principal component of $\mathbf{x}$ is $\alpha_k'\mathbf{x}$ with variance equal to (Jolliffe, 2002):

$$\text{var}(\alpha_k'\mathbf{x}) = \lambda_k, \quad \text{for } k = 1, 2, \ldots, p, \tag{8}$$

where λ_k is the kth largest eigenvalue of Σ and α_k is the corresponding eigenvector. The elements of the vector α_k are the unrotated factor loadings correspondent to the kth principal component.

Figure 21 shows a graphical example adapted from Jolliffe (2002). In this simple case, the dataset contains two variables x_1 and x_2. Observations are presented in a scatter plot with x_1 in the horizontal axis and x_2 in the vertical axis. It can be noticed that there is considerable variation in both variables, though rather more in the direction of x_1 than x_2. If a principal component analysis is run, two principal components are identified, f_1 and f_2. From the graph, it appears clearly that there is greater variation in the direction of f_1 than in either of the original variables but very little variation in the direction of f_2. More generally, in datasets with more than two dimensions and correlated variables, few principal components account for most of the variation in the original variables; whereas the last few principal components represent directions in which there is very little variation.

The terms factor and principal component are often erroneously used as synonyms, although they are not. "Principal component" can be used within the principal component analysis, whereas "factor" is related to the factor analysis. Generally, they are different (because of the differences in their derivation); however, in the principal component factor analysis, the unrotated factors and the principal components are exactly the same.

Once all the factors (or principal components) have been identify, the following step is to retain the relevant ones. There are several methods to choose how many factors should be retained (Jolliffe, 2002). In this work, three methods are used to select the number of factors: the *Kaiser's rule* (Kaiser, 1960), the scree plot (Cattell, 1966) and the parallel analysis (Franklin *et al.*, 1995). The first method is the most commonly used. It selects all the factor with a corresponding eigenvalue greater than or equal to one[2]. According to Jolliffe (2002), the idea behind the Kaiser's rule is that if all the original variables are independent, then the factors are the same as the original variables. In this case, all the factors are going to have unit variances and, under some conditions, an eigenvalue equal to 1. Thus, any factor with variance less than 1 contains less information than one of the original variables.

The scree plot method is a subjective graphic analysis of the plot of the eigenvalues against their correspondent factor. According to Cattell (1966), it is important to identify in the curve a more-or-less straight line, not necessarily horizontal. The first point on the straight line is then taken to be the last factor to be retained. If there are two or more straight lines formed by the lower eigenvalues, then the first line from the left is considered. In the example presented in Figure 22 the first straight line from the left seems to

[2]The eigenvalue related to a specific factor derives from the principal components analysis (see equations (6)–(8) and is a common outcome in all statistical software.

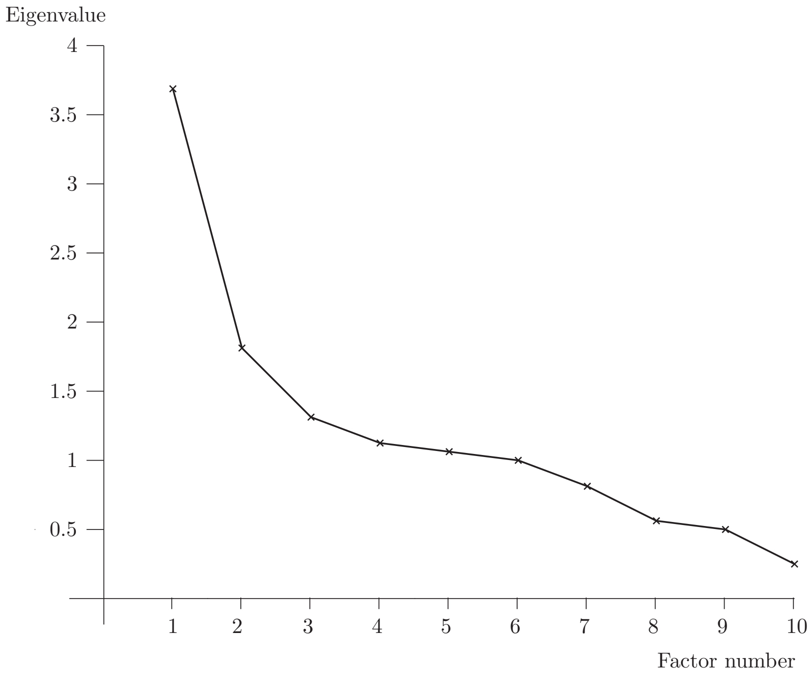


Figure 22: An example of scree plot.

pass through the points corresponding to the fourth, fifth and sixth factors. Therefore, the fourth factors should be kept.

In the parallel analysis, a random dataset with the same numbers of observations and variables as the original data is created. A correlation matrix is estimated from the randomly generated dataset and then eigenvalues of the correlation matrix are computed. When the eigenvalue of a certain factor derived from the random data is larger than the eigenvalue of the factor found from the principal component factor analysis, it is likely that the latter factor represents mostly random noise. Therefore, it should not be retained.

Once the number of relevant factors is found, the following step is to rotate the factor axis with the objective of making easier the interpretation of the results (Harman, 1976). The most popular option is the varimax rotation (Jolliffe, 2002). It is is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor on all the variables. The criterion tends to drive factor loadings towards -1, 0 or 1 and away from intermediate values making as easy as possible the identification of each variable with a single factor. Under some assumptions[3], the resulting factor loadings after a varimax rotation have the property of representing the correlation between variables and factors (Jolliffe, 2002).

Finally, in this thesis, the factors are identified and interpreted by assigning each original variable to the factor with which it has the higher positive rotated factor loadings. A similar methodology is found in Bradley *et al.* (2004).

[3]See Jolliffe (2002, p. 25) for more details.

C Appendix: principal component analysis results

C.1 Principal component analysis for the Danish population's data: rotate and unrotated results

Table 22 presents the correlation coefficients (also called factor loadings) between factors and pictures' scores by the general public. In the right part of Table 22, cross correlation coefficients between the rotated factors and the pictures' scores are showed after the varimax rotation was run.

In the interpretation of the table exclusively loadings higher than 0.3 are considered. Factor 1, which represents 43% of the total variation, is positively related to pictures 201, 207, 217 (and 210, to a smaller extent) and negatively related to pictures 203, 205, 211 and 215. It is worth to notice, that the two groups of photographs identify respectively the low to very low (100–300 stems ha^{-1}) and the high to very high (5300–7000 stems ha^{-1}) residual stem density. Factor 2 accounts for about 12% of the total variation. It is strongly positively correlated with pictures 208 and in a lower degree with picture 215. These two pictures are the only two scenes depicting a distinct row structure, although they show stands with different residual stem density. Factor 2 shows a feeble negative correlation with photographs representing open or very open stands (picture 207 in the unrotated results and picture 211 in the rotated results) or very dense stands (picture 205 in the rotated results) without any apparent row structure. After the variation in the scores has been accounted by factor 1 and 2, the third source of variation (factor 3) has a high positive correlation with picture 220 in contrast with a minor negative correlation with pictures 215 and 210.

Results from the principal component analysis relative to the professionals and students are presented in Table 23. The same procedure used for the general public was applied. A varimax rotation was run after the selection of the factors. Individual scenes with a loading on a particular factor lower than 0.3 were non considered relevant for that factor. Factor 1 accounts for almost 40% of the scores' variability in the experts dataset. In both the unrotated and rotated results, it has a strong positive correlation with pictures depicting very dense to dense stands (7000–5300 stems ha^{-1}) and a sound negative correlation with pictures showing low to very low densities (300-100 stems ha^{-1}). However, after the rotation, low densities stand photographs (pictures 201 and 210) present a lower degree of influence on the factor (i.e. picture 210 is has a loading of –0.18), whereas the importance of very low density pictures is reinforced. Factor 2 contrasts mid range stands

Table 22: Unrotated and rotated (varimax) correlation coefficients between factors and pictures' scores based on principal component factor analysis of the Danish general public data.

	Unrotated			Rotated		
Picture	Factor1	Factor2	Factor3	Factor1	Factor2	Factor3
215	−0.66	0.36	−0.33	−0.71	0.08	−0.32
205	−0.76	−0.27	0.14	−0.66	−0.48	−0.05
211	−0.81	−0.2	0.14	−0.73	−0.44	−0.04
203	−0.79	−0.11	−0.06	−0.71	−0.29	−0.21
208	0.27	0.84	−0.23	0.03	0.91	0.04
220	0.24	0.27	0.87	0.09	0.05	0.94
210	0.35	−0.24	−0.31	0.43	−0.04	−0.3
201	0.83	−0.12	0.05	0.82	0.09	0.14
207	0.74	−0.34	−0.25	0.82	−0.04	−0.22
217	0.75	−0.10	0.07	0.74	0.08	0.16
Eigenvalue	4.36	1.23	1.15			
Percentage of variance explained	43.6	12.3	11.5			

Table 23: Unrotated and rotated (varimax) correlation coefficients between factors and pictures' scores based on principal component factor analysis of the Danish forestry professionals, green professionals and natural resources students.

	Unrotated			Rotated		
Picture	Factor1	Factor2	Factor3	Factor1	Factor2	Factor3
215	0.68	0.28	−0.3	0.57	0.23	−0.51
205	0.68	−0.53	−0.05	0.41	−0.6	−0.45
211	0.72	−0.43	0.24	0.59	−0.61	−0.2
203	0.81	0.02	0.07	0.74	−0.16	−0.29
208	0.02	0.83	−0.39	0.13	0.88	−0.18
220	−0.09	0.68	0.39	0.27	0.52	0.52
210	−0.52	0.08	0.66	−0.18	−0.03	0.82
201	−0.74	−0.19	−0.08	−0.74	−0.01	0.22
207	−0.69	−0.29	−0.42	−0.85	0	−0.12
217	−0.74	−0.28	−0.07	−0.77	−0.09	0.21
Eigenvalue	3.96	1.88	1.07			
Percentage of variance explained	39.6	18.8	10.7			

(pictures 208 and 220) with high and very high density stands (205 and 210) and represents approximately 19% of the total scores' variation. Loadings for factor 2 are similar in both the unrotated and rotated results. The last factor exhibits a sound positive correlation with picture 210 (300 stems ha^{-1}) and, to a smaller extent, with picture 220 (1000 stems ha^{-1}). This is valid both for both types of loadings. Turning to the negative significant loadings, the results tend to change from the unrotated to the rotated case. As a matter of fact, in the first case factor 3 contrasts picture 210 and 220 with picture 208 (1000 stems ha^{-1}) and 207 (100 stems ha^{-1}); while in the second case, relevant negative loadings are found for picture 205 and 215 showing stands with a very high density (7000 stems ha^{-1}). In summary, from the principal component factor analysis it emerged that the scores variability in both subgroups (the general public and experts) is mostly explained by three latent variables or factors. However, the factors in the two datasets are different due to different correlations with the pictures.

C.2 Principal component analysis for the European forestry professionals' data: rotate and unrotated results

Table 24: Unrotated and rotated (varimax) correlation coefficients between factors and pictures' scores based on principal component factor analysis of the European forestry professionals' data.

	Unrotated			Rotated		
Picture	Factor1	Factor2	Factor3	Factor1	Factor2	Factor3
215	0.62	0.19	−0.09	0.59	0.06	−0.30
205	0.73	−0.40	−0.16	0.53	−0.55	−0.38
211	0.80	−0.28	0.05	0.69	−0.45	−0.21
203	0.81	−0.01	0.07	0.77	−0.19	−0.20
208	−0.12	0.83	−0.32	−0.04	0.85	−0.28
220	−0.08	0.72	0.25	0.17	0.71	0.25
210	−0.42	−0.10	0.83	−0.14	−0.05	0.93
201	−0.79	−0.21	−0.09	−0.80	−0.03	0.18
207	−0.76	−0.28	−0.37	−0.88	−0.09	−0.10
217	−0.79	−0.19	−0.06	−0.79	−0.01	0.21
Eigenvalue	4.26	1.66	1.05			
Percentage of variance explained	42.6	16.6	10.5			

Table 24 presents the correlation coefficients (also called factor loadings) between factors and pictures' scores for the European forester dataset. In the right part of the table, cross correlation coefficients between the rotated factors and the pictures' scores are presented.

In the interpretation of the factors, individual scenes with a loading on a particular factor lower than 0.3 are not considered relevant for that factor. Factor 1 accounts for 42.6% of the scores' variability. In both the unrotated and rotated results, it has a strong positive correlation with pictures depicting very dense to dense stands (7000Ű5300 stems ha^{-1}) and a sound negative correlation with pictures showing low to very low densities (300-100 stems ha^{-1}). After the rotation, picture 210 is present a very low factor loading. Factor 2 contrasts pictures 208 and 220 (1000 stems ha^{-1}) with picture 205 (7000 stems ha^{-1}). After the rotation, the factor presents similar positive correlations with picture 208 and 220 and negative correlation with picture 205 and 211. The third factor exhibits a sound positive correlation with picture 210 (300 stems ha^{-1}). Negative relevant loadings tend to change from the unrotated to the rotated results. In the first case, picture 207 (100 stems ha^{-1}) and 208 (1000 stems ha^{-1} are considered as relevant; in the second case only picture 205 (7000 stems ha^{-1}) has a significant negative correlation.

C.3 Principal component analysis for the European students' data: rotate and unrotated results

Table 25: Unrotated and rotated (varimax) correlation coefficients between factors and pictures' scores based on principal component factor analysis of the European natural resources students' data.

	Unrotated			Rotated		
Picture	Factor1	Factor2	Factor3	Factor1	Factor2	Factor3
215	−0.57	0.16	−0.47	−0.50	−0.37	0.43
205	−0.79	−0.24	−0.09	−0.72	−0.39	−0.12
211	−0.74	−0.29	0.16	−0.71	−0.23	−0.32
203	−0.75	−0.05	0.25	−0.76	−0.02	−0.19
208	0.17	0.75	−0.43	0.14	0.19	0.85
220	0.14	0.68	0.57	−0.06	0.89	0.15
210	0.49	−0.12	0.45	0.42	0.36	−0.38
201	0.78	−0.12	−0.17	0.81	−0.04	0.01
207	0.72	−0.38	−0.25	0.80	−0.27	−0.13
217	0.71	−0F.20	0.07	0.70	0.08	−0.21
Eigenvalue	3.98	1.43	1.13			
Percentage of variance explained	39.8	14.3	11.3			

Table 25 presents the factor loadings between factors and pictures' scores, reulting from the principal component analysis. The cross correlation coefficients between the rotated factors (varimax rotation) and the pictures' scores are showed in the right part of Table 25. Exclusively loadings higher than 0.3 are considered in the interpretation of the table.

Factor 1 represents around 40% of the total variation and it contrasts photographs identifying respectively the low to very low (100–300 stems ha^{-1}) and the high to very high (5300–7000 stems ha^{-1}) residual stem density. Factor 1 remained unchanged before and after the rotation. This was not the case for Factor 2 and Factor 3. Factor 2, accounting for about 14% of the total variation, has a high positive correlation with picture 220 and 208 in contrast with a minor negative correlation with pictures 207. Then, it seems to contrast mid density stands' photographs with low density stand's. The rotated Factor 2 is positively correlated with picture 220 and, to a smaller extent, picture 210, but not with picture 208. It is negatively correlated with pictures 215 and 205 depicting very dense stand. Hence, the rotated Factor 2 focus more on the contrasts between medium to open stands and very dense stands. Factor 3 is focussed on the contrast between the picture 208 and 215 with picture 210. The rotation changes the sign of the correlation coefficients. The unrotated Factor 3 is positively related with picture 210 and 220 and negatively related to picture 208 and 215. In contrast, the rotated Factor 3 is positively related to picture 208 and 215 and negatively related with picture 210 and 211.